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EFFECTS OF URBAN EXPANSION ON COASTAL VEGETATION ECOSYSTEMS CONSERVATION AND FUNCTIONING IN BUFFALO CITY METROPOLITAN MUNICIPALITY, SOUTH AFRICA

A thesis submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy (PhD) in Geography, in the Department of Geography and Environmental Science, Faculty of Science and Agriculture, University of Fort Hare, South Africa.

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DECLARATION

I, OLATOYE, Tolulope Ayodeji, hereby declare that the content of this thesis is my original work and has not been previously submitted to any other university for any other degree in part, or in its entirety. All published and unpublished materials I consulted in the course of writing this thesis are duly acknowledged. It is important to note that three papers (chapters two, five, six and seven) have been published and others are at different stages of publishing under different DHET accredited journals.

Signature: --------------------------------------

Date: **July 14, 2021**

DEDICATION

All my hope on God is founded, He will all my strength renew. I dedicate this thesis to the Alpha and Omega, and give Him the glory for the great things He has done. I also remember my late Mum of blessed memory, Evangelist (Mrs.) Lydia Ekunsola Olamijulo Olatoye, continue to rest in the bosom of our Lord. Furthermore, I dedicate this research to my aged, loving and “one in a million” Dad, Dr. Samuel Tanimowo Banjoko Olatoye, who demonstrated and taught me four ‘Hs’ in life, (that is, Honour for God, Humility, Honesty and Hard work). This thesis is also dedicated to my precious Queen IbukunOluwa Oluwayemi Olatoye, for unending love and continued support, and my precious angels- Jemimah and Jeremiah Olatoye.

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ABSTRACT

Coastal urban expansion is on an upward trajectory, which poses serious threats to ecosystem functioning, human wellbeing and the general environment across the globe. It is on this premise that this study brings to the fore the growing complexity of environmental sustainability problems in a former apartheid space, as characterized by coastal urbanization and the intricacies of vegetation conservation. Consequently, literature utilized for this study reveals that urban expansion has led to an uncontrolled threat to the coastal ecosystem, culminating in soil erosion, environmental pollution through illegal dumping of solid waste, loss of coastal vegetation to other land use types, among others. Therefore, constant monitoring of these spaces is needed due to their fragility, as they are pivotal in the earth-atmosphere processes to the benefit of the entire humanity. To this end, the current study offers critical analysis and insights about the South African coastal ecological space. The essence of using BCMM in its consideration as an ecological space and former apartheid territory brings to the fore a scientific explanation of the spatial configuration and changes in the CVEs of the study area during the post-colonial era. In the course of investigating this study, the Urban Green Sustainability (UGS) theory was adopted in the course of selecting the review of literature, methodological approach and analysis of results. A mixed methodological approach (qualitative, quantitative and geospatial techniques) was explored in data collection and analysis. 254 copies of the questionnaire were returned and analysed for this research. Results generated revealed by the BCMM respondents confirms the occurrence of uncontrolled urbanization, deforestation and crop cultivation as major causes of coastal vegetation loss. In the same vein, the LULC classification results revealed that about 466 km^2 of forest vegetation has been lost in BCMM from 1998-2018. Also, LULC classification results were validated by performing the Normalized Difference Built-Up Index (NDBI), Normalized Difference Vegetative Index (NDVI), Kappa's coefficient (k), coefficient of determination (R^2) and Pearson's Product Moment Correlation (P) tests. The results also revealed that the built-up area had increased from 194 km^2 in 1998 to 814 km^2 in 2008. Further, all statistical tests revealed very good and highly correlated overall classification accuracies (of R^2=0.89 and P=0.86) during the study period (1998 – 2018). This study makes a clarion call towards the rehabilitation of degraded coastal environments and proffers solutions towards the actualization of environmentally sustainable CVEs which offers optimal ecosystem services.

KEYWORDS: *Coastal Vegetation Environments; Buffalo City Metropolitan Municipality; Conservation; Ecological Conservation; Environmental Degradation; Geospatial Technologies; Land Use Land Cover Change (LULCC); Remote Sensing; Urban Expansion.*

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ACRONYMS

AR	Actively Restorable
BCMM	Buffalo City Metropolitan Municipality
BI	Biodiversity Intactness
BPI	Biodiversity Priority Index
CASI	Compact Airborne Spectrographic Imager
CBNRM	Community-Based Natural Resource Management
CBA	Critical Biodiversity Areas
CBO	Community-Based Organization
CDM	Cleaner Development Mechanism
CNC	Critical Natural Capital
CVEs	Coastal Vegetation Environments
DEM	Digital Elevation Model
DAAF	Department of Agriculture, Forestry and Fisheries
EIA	Environmental Impact Assessment
EL	East London
ES	Ecosystems Services
ESI	Ecosystem service index
GIS	Geographic Information Systems
IDP	Integrated Development Project

ISI	Information Services Index
KWT	King William's Town
LiDAR	Light Detection and Ranging
LULC	Land Use, Land Cover
LULCC	Land Use, Land Cover Change
MAB	Man and Biosphere Programme
MLC	Maximum Likelihood Classifier
MEA	Millennium Ecosystem Assessment
MOSS	Municipal Open Systems Space
MSA	Municipal Systems Act
NGO	Non-Governmental Organization
NSBA	National Spatial Biodiversity Assessment
OBC	Object-Based Classification
OBIA	Object-Based Image Analysis
OLI	Operational Land Imager
PBC	Pixel-Based Classification
PCSI	Productive and Cultural Services Index
PES	Payment for Ecosystems Services
PR	Passively Restorable
RS	Remote Sensing
SDF	Spatial Development Framework

SSC	Species of Special Concern
SPOT	Satellite Pour l'Observation de la Terre
STEP	Subtropical Thicket Ecosystem Planning
UFH	University of Fort Hare
UNEP	United Nations Environmental Project
UNESCO	United Nations Educational, Scientific and Cultural Organization

CHAPTER ONE

INTRODUCTION AND STUDY BACKGROUND

1.1 INTRODUCTION

Several studies on coastal vegetation (such as Nyland 2016) disclosed that it forms a fundamental proportion of resources used to determine the potential of any given land. Vegetation accounts for two-thirds of all different types of terrestrial ecosystems in tropical, sub-tropical, temperate, Mediterranean and boreal regions (Botez, 2013). From the foregoing, terrestrial ecosystems offer an enormous variety of functions, which include sequestration of carbon, conservation of biodiversity, water supply, flood control, protection against soil erosion and desertification (Cowie, 2011).

1.2 DEFINITION OF KEY TERMS

Vegetation: This is defined by Watson, (2014) as an accumulation of plant species on the ground cover on which they are sustained. It also refers to a broader variety of plant communities. Vegetation is further defined as distinguishing dominant species, or a common aspect of the assemblage, such as environmental commonality or elevation range (Moffett, 2016; Zhao, 2016).

Conservation: This is conceptualized as the cautious protection and safeguarding of a treasured resource, such as the premeditated and deliberate management of a natural resource so as to prevent its damage, misuse, neglect or exploitation (Clewell, 2013).

Coastal Vegetation Environments (CVEs): CVEs are those areas which are typified by the ecological interactions of land, vegetation and the oceans (Chapman, 2016). CVEs are special environments where the marine, terrestrial and vegetal areas impact each other (Watson, 2014).

Urban Expansion: Rojas (2019) conceptualized urban expansion as the practice of creating or generating the built environment to accommodate populations and human interventions in urban areas, which concomitantly alters LULC, biogeochemistry, habitats, the balance of earth surface and energy, hydrology, and so on. The emphasis of urban expansion in this study focused on its influence on CVEs in Buffalo City Metropolitan Municipality.

Environmental Sustainability: The sustainability of the environment refers to a process that ensures environmental management vis-a-vis the exploitation of resources sustainably without compromising the opportunities of future generations to utilize these resources (Wu, 2014). As also indicated by (Emas, 2015), sustainable development is a process of ensuring that the utilization of resources, so as to meet the needs of the present generation without compromising the ability of future generations to meet their own needs (Griggs, 2013).

Geographic Information Systems (GIS): Green (2017) conceptualized GIS as a computer-based system, which deals with the collection, storage and analysis of geo-spatial data about the earth. GIS is also epitomized as an assembly of computer hardware, software and users of the technology to make up an entire system, which collects, stores, manipulates and displays spatial information about the earth (Bolstad, 2014). According to Li (2011), GIS is hinged on the incorporation of three computer technology-based aspects namely software for editing, georeferencing, presenting & plotting data; Database management system (for processing and analysing graphic & non-graphic data) as well as statistical techniques, and algorithms for query operations and spatial analysis.

Image Classification: Dian (2015) defined image classification as the art of retrieving information classes from a multiband rasterized data for the creation of thematic maps. Disney (2016) have put forward two classification types namely: supervised and unsupervised, and these classifications can be performed with the utilization of the multivariate toolset functionality in ArcGIS Spatial Analyst extension (version 10.8). Not only does the toolbar help with the workflow for performing unsupervised and supervised classification, but it also comprises added functionality for processing input data, as well as the creation of signature files and training samples.

Remote sensing: Remote sensing is crystallized by Adão (2017), as the science involving the acquisition of information about the biosphere, without actually being in close contact with it, as it is usually done from far distances. This is done by identifying and recording emitted or reflected energy (from distant objects or materials, through the identification and categorization by class/type, the spatial configuration of earth landscapes) processing, analysis, and application of that information. Houborg (2015) opined that it is a procedure involving the detection and measurement of radiated wavelengths reflected or emitted. Remote sensing methods have been verified to be great tools for mapping and classification of land use and land cover (LULC) phenomena such as vegetation, water and soil, of the earth on local, regional and global scales. The research problem is discussed in the next section.

1.3 RESEARCH PROBLEM

Coastal Vegetation Environments (CVEs) in the study area are characterized by fragile ecosystems, which require constant monitoring and provide updated information for timely interventions that promote sustainability (Gardner, 2010). This is because, CVEs sustain high biodiversity (Lefcheck, 2015), as well as providing food and livelihoods for human populations that surround them (Mbolambi, 2016; Siyongwana, 2017; BCMM Report, 2017). Other environmental problems resulting from urban expansion in BCMM include an increase in alien invasive species in sensitive areas of indigenous endemism; illegal dumping of toxic waste, and the main concern from an environmental perspective, is the occurrence of unsustainable coastal land use. These threaten the local resource-base, which rural communal livelihoods are dependent upon, hence, the urgent need to know the status of the resource to ensure sustainable communities (Manyefane, 2014).

According to the Provincial Gazette for Eastern Cape, (2014), over 40% of the coastal vegetation are threatened in South Africa. In addition, BCMM has recorded the second highest population changes in the Eastern Cape from 1996 to 2011, at an alarming rate of 9.2% (Sinuka, 2017). However, the present status in terms of extent, nature, species richness and local people's perception are unknown despite the increasing urbanization in the area. Further, Hoppe-Speer, (2012) opined that CVEs are greatly threatened and are depleting fast in BCMM due to human factors.

These have been found to jeopardize these natural habitats (Neumann, 2015; Feist, 2016), causing vegetation loss and affecting critical benefits (Manyefane, 2014), invasion by introduced species and pollution (FAO, 2012) and triggering climate change (Sustainable Development Solutions Network, 2010). It was also discovered in the literature (such as Pillay, 2010; Sinuka, 2017) that BCMM has witnessed uncontrolled urban expansion in form of disaggregated urban settlements extending on the periphery of the existing major towns of East London and King William's Town. The satellite suburbs of Mdantsane and Dimbaza (but also Beacon Bay and Gonubie) are the most obvious manifestations of this. In the last 20-30 years, however, there has been a growing recognition in BCMM regarding patterns of human settlement, which need to be managed and reconfigured, to take into account increasing demands for living space, public goods, services, and economic development, as well as challenges such as availability of water, energy fuels and arable land (Turok, 2012). In addition, the multiple threats presented by climate change and environmental degradation associated with sprawling urban cities are now being recognized more clearly in the study area (BCMM Report, 2017). Against this background, there has been an increase in the overall density of urban environments as well as a more flexible approach to spatial development, which takes into account the need to promote more sustainable forms of settlement development. It is observed from empirical studies that several studies have focused on coastal degradation in many provinces in South Africa, however, there is insufficient literature on ecosystems functioning as well as the impact of urban expansion on CVEs in the study area. Additionally, there is inadequate geo-spatial information in the literature regarding the degree of coastal vegetation loss in the study area. It is on this premise that this study investigates ecosystem functioning and the impact of urban expansion on the conservation of CVEs. The subsequent section states the aim of this study.

1.4 AIM OF STUDY

To investigate the effects of urban expansion on coastal vegetation ecosystems conservation and functioning in Buffalo City Metropolitan Municipality, Eastern Cape Province, South Africa.

1.5 RESEARCH QUESTIONS

The research questions guided this study, which investigated the To investigate the effects of urban expansion on coastal vegetation ecosystems conservation and functioning in Buffalo City Metropolitan Municipality, Eastern Cape Province, South Africa, and they include the following:

(1.) How effective is the implementation of the Spatial Development Framework (SDF) and the Integrated Development Plan (IDP) regarding coastal vegetation ecosystems conservation at BCMM?

(2 What are the perceptions of BCMM inhabitants regarding obtainable ecosystem goods, services and economic benefits derivable from the study area?

(3.) What are the perceptions of BCMM inhabitants concerning the impact of urban expansion on coastal vegetation environments in the study area?

(4.) What is the aerial extent of land use and land cover changes (LULCC) influence on vegetation due to urbanization at Buffalo City Metropolitan Municipality from 1998-2018?

1.5.1 Study Objectives

The study objectives for this study include the following:

- To critically assess the performance and implementation of the Integrated Development Plan and the spatial development framework regarding the conservation of the coastal vegetation of Buffalo City Metropolitan Municipality (BCMM)
- To examine the ecosystem function, and the conservation of ecological goods, services and economic benefits derivable from coastal ecological systems by BCMM residents.
- To determine the impact of urban expansion on the conservation of coastal vegetation Environments in BCMM.
- To investigate the coastal vegetation LULCC detection of BCMM from 1998 to 2018 using geo-spatial technologies.

1.6 THE URBAN GREEN SUSTAINABILITY (UGS) THEORY

According to Anfara and Mertz, (2014), the merits of adopting theoretical frameworks in research are as follows: It serves as a platform upon which the investigator can critically examine and advance the applicability of the model or theory, as well as encapsulating and methodically defining research techniques. Also, it guided the researcher in explore coastal vegetation land use changes, thereby providing an explanation of the intricacies of coastal vegetation management and conservation. From the myriad of studies on the conservation of coastal vegetation environments, many theories have been proposed to explain the concept in literature, and these include (i) Environmental Impact Assessment Theory (Zvijáková, 2014) (ii) The Ecosystem Adaptative Theory (Allen, 2015) (iii) Urban Green sustainability (UGS) (Liang, 2017). For the purpose of this research, the Urban Green sustainability (UGS) Theory was adopted. UGS Theory aims to stimulate ecosystem health and resilience, consolidate efforts on biodiversity conservation and enhance ecosystem services (Jennings, 2016). The essence of the UGS Theory for this study is to provide clarifications and solutions to the research problem as well as providing a clearer perception regarding the need to conserve the fragile CVE of the study area. As elucidated by Konau, (2016), the theory provides network features of natural and semi-natural, in addition to coastal, urban, rural, terrestrial and marine green spaces. Also, Jennings (2016), and Konau (2016) posited that UGS Theory incorporates natural phenomena, such as coastal vegetation reserves, forest reserves, hedgerows and parks in order to ensure that they are intact and restored. Furthermore, UGS Theory enhances ecosystem services, which are central to both the environment and sustainability of the biosphere (Sandifer, 2015). Also, UGS Theory advances the integration of spatial planning efforts through the identification of multi-functional zones and incorporating ecosystem restoration procedures and processes into land-use planning and policy documentation (Jennings, 2016), which is sine-qua-non to environmental sustainability and South African coastal biodiversity conservation (Haaland, 2015). Conceptualizing the UGS theory provided substantiation for the reviewed literature, strengthened the research elements of this study and the correlations that exist among them. Also, UGS theory helped to offer structural and scientific interpretation to the research design and helped to analyze the study objectives for this study in the following ways: The UGS

Theory is aligned with Study Objective One, because it helped to evaluate the effectiveness of the policy framework for the study area, namely the Integrated Development Plans (IDP) and Spatial Development Plans (SDF) as well as their future implications in ensuring sustainability of CVEs in BCMM, while in Study Objective Two, the UGS theory provided guidance in the assessment of ecosystem health, quality, resilience as well as enhancing ecosystem services provision. Furthermore, the UGS theory provided solutions to unravelling Study Objectives Three and Four by enhancing the sustainability of the endangered BCMM CVEs as well as inspiring consolidation efforts geared towards biodiversity conservation. Hence, the applicability of the UGS Theory cannot be over-emphasized, due to the fact that it provides scientific contributions to the actualization of the overarching aim of this study, as well as providing guidance in the analysis of the research questions, and detailed explanations which guided the choice of research methodology, hypotheses generation and the consequent interpretation of research findings in the chapters 5, 6, and 7 of this study. hence, the theory made provision for the substantiation of scientific facts. This leads to the discussion on the significance of this study, as presented in the subsequent section.

1.7 SIGNIFICANCE OF THE STUDY

This research contributes to ecological science through the conservation and protection of rare, endemic and endangered coastal vegetation resources of the study area, which are largely endangered. In coastal areas, the focus of research has largely been on coastal protection, to mitigate and adapt to sea level rise and coastal hazards, both present and future (Lawrence, 2018), which is fundamental to ecosystems functioning and sustainability (Kumar, 2012; Maes, 2013; Anderson, 2014; Mendoza-Fernández, 2014; Midgley, 2015). This research provides insight into the process of coastal vegetation protection, conservation and management. From the foregoing, the outcome of this study provides recommendations to assist government, forest managers, environmentalists, ecologists, city managers/planners and other stakeholders to establish sustainable coastal vegetation management approaches. In general, this research contributes to science in several ways, for example, this research contributes to knowledge regarding the growing complexity of environmental sustainability problems experienced in the study area, being a former apartheid space, characterized by coastal urbanization and the intricacies of vegetation conservation (Adegun, 2018), and this is further explained in chapter eight.

Secondly, this research helps to adopt a formal problem-solving framework to ecological sustainability and management challenges; thirdly, this research helps to bridge the implementation gap between ecological science and practice; and fourthly, this research provides the required information needed to ensure ecological sustainability and restoration ecology (Miller, 2017) at both a local and national scales (as recommended in chapter eight). This study also underscores the need for rehabilitation of coastal degraded environments and proffers solutions towards environmentally sustainable management of coastal vegetation resources and adaptation to environmental changes (Imeson, 2012; Ding, 2015). Further, this study contributes to the realization of Operation Phakisa Programme and Priority Area 7 of the Provincial Gazette Document for the Eastern Cape 2014, which centres on awareness, education, training, capacity building and information dissemination regarding environmental conservation.

1.8 STRUCTURE OF THE THESIS

The content of the chapters comprising this thesis is presented in the form of paragraphs reflecting the specific content covered in each chapter. This study comprises of eight chapters, with each chapter starting off with an introduction and concluding with a summary.

Chapter One: Introduction and Study Background

Chapter one briefly introduced the concept of ecosystem functioning, urban expansion, coastal vegetation environments and conservation. A general background to the study, highlighting the problem statement, research questions and study objectives, as well as the significance of the study were also provided. Furthermore, the problem of study and conceptual framework, upon which this thesis is underpinned thesis were discussed within this chapter. The chapter also provides an introduction to the conceptual framework (Urban Green Sustainability), expected outcomes from the study and ethical considerations.

Chapter Two: Review of Existing Literature on the effects of Urban Expansion On Coastal Vegetation Ecosystems Functioning and Conservation

Chapter two provides a review of related empirical and theoretical literature upon which the foundation of this study is laid. The consulted books, journal articles and other reference sources for the entire thesis ranged from the year 2010 to 2019. These literature are centered on coastal vegetation, urban expansion, the challenges of coastal vegetation and urbanization in the international scene, the paradox of urban expansion and coastal vegetation sustainability, concept of Geographic Information Systems, and schools of thought about change detection studies.

Chapter Three: Research Methodology

Chapter Three discussed the research methodology adopted for the study, and these include the research methods, population of the study, research design, techniques for data collection and data analysis. The data collection methods include questionnaire research approaches (such as qualitative and quantitative). Additionally, this thesis utilized the survey research design, and the data collection method was the questionnaire. The methodology adopted for this study guided the researcher to unravel the assertion that urban expansion has negatively impacted the conservation of coastal vegetation in BCMM, and this is in line with the total findings of this study.

Chapter Four: A critical assessment of the performance and implementation of the integrated development plan and spatial development framework regarding the conservation of the coastal vegetation of Buffalo City Metropolitan Municipality (BCMM)

This chapter critically evaluated the implementation of the Integrated Development Plan (IDP) and Spatial Development Framework (SDF) of BCMM, as well as problems that affect the spatial development framework of BCMM.

Chapter Five: The Conservation of Obtainable Goods, Services and their Economic Benefits in the Study Area.

This chapter provides information on the categories of ecosystem functions (namely provisioning, cultural and regulation functions). Further, research findings from the questionnaire pertaining to the ecosystem functions, goods, services and economic benefits derivable from the study area were presented. This chapter also presents five (5) research hypotheses which sought to analyze the relationship between knowledge of ecological conservation and ecosystems functioning, and these were analyzed through the logistic regression technique to determine the Odd Ratio, p values, Confidence Interval (CI, at 95% levels of significance), as well as Hosmer and Lemeshow's Chi-Square (χ^2) statistics.

Chapter Six: Impact of Urban Expansion on the Conservation of Coastal Vegetation Environments (CVEs) in BCMM.

Chapter Six sought to conceptualize the study objective three, which was to investigate the influence of urban expansion on coastal vegetation in the study area. In doing justice to this chapter, the importance and challenges of coastal vegetation management, as well as coastal vegetation loss, were clearly expatiated. This chapter also presents seven (7) research hypotheses, which sought to analyze the relationship between knowledge of ecological conservation and the challenges associated with urban expansion, and these were analyzed through the logistic regression technique.

Chapter Seven: Geospatial Analysis Of Landuse Landcover Change (LULCC) Detection of Coastal Vegetation Loss at BCMM from 1998-2018.

This chapter focuses on the geo-spatial mapping and time series change detection analysis of the coastal vegetation of BCMM from 1998, 2008 and 2018 Landsat imageries using Geographic Information Systems and Remote Sensing Technologies. Assessment of the pattern and magnitude of changes in the LULC through various multi-temporal satellite data. Image pre-processing was also performed to extract meaningful information from satellite data for the purpose of easy interpretation. Change detention analysis was done in ArcGIS 10.8 Environment. The author also validated the LULC classification results by performing the Normalized Difference Built-Up Index (NDBI), Normalized Difference Vegetative Index (NDVI), and concluded the study by validating the classification results by carrying out the coefficient of determination (R^2), Kappa coefficient (k) and Pearson's Product Moment Correlation (*P*) tests, and the tests revealed very good and highly correlated overall classification accuracies (of R^2=0.89 and P=0.86) during the study period.

Chapter Eight: Summary, Conclusion and Recommendations

This chapter provides a synopsis of the introduction, the review of relevant literature, theoretical framework, methodology, the spatial development framework of the study area, BCMM ecosystem goods and services, the concepts of urban expansion and coastal vegetation conservation, the effects of urban expansion on the study area, geo-spatial mapping and time series change detection analysis of the study area, and a summary of the research findings, conclusions and recommendations based on the investigated study objectives were summarized in this chapter.

1.9 CONCLUSION

This chapter presented an introduction and background to the study, which focused on the effects of urban expansion on coastal vegetation ecosystems conservation and functioning in Buffalo City Metropolitan Municipality, Eastern Cape Province, South Africa. This study is necessitated due to the adverse effects of urban expansion in the study area, which has led to an uncontrolled threat to the coastal ecosystem culminating in the extinction of endemic species of flora and fauna, loss of habitat for wildlife, disruption of microbial activities and soil metabolism required for vegetal growth, change in the micro-climatic conditions of the study area, soil erosion, environmental pollution through illegal dumping of solid waste, loss of vegetation LULC to other land use types among others. The chapter also discussed the study area, core argument, research problem, research questions, study objectives, study area, the significance of the study, and a description of the study area were briefly discussed. The chapter further discussed the structure of this thesis, as well as the theoretical framework (the Urban Green Sustainability- UGS theoretical foundation, which justifies this research with empirical authentication and empowered the articulation of the study objectives of this research. Furthermore, this chapter highlights the key constructs of this study. These constructs have largely informed the next chapter, which is the review of relevant literature on ecosystem functioning and the impact of urban expansion on the conservation of coastal vegetation environments.

CHAPTER TWO

REVIEW OF EXISTING LITERATURE ON THE EFFECTS OF URBAN EXPANSION ON COASTAL VEGETATION ECOSYSTEMS (CVEs) CONSERVATION AND FUNCTIONING

2.1 INTRODUCTION

With reference to the effects of urban expansion on coastal vegetation ecosystems functioning and conservation, this doctoral research is the first of its kind, and is therefore considered very apt and timely because of the ecological challenges and intricacies associated with the spatial development of a former apartheid space. [1]. It is also imperative to note that the literature reviewed for this research is rich, diversified and developed based on relevant themes in the specific field of study. Relevant literature on ecosystem functioning, urban expansion, coastal vegetation environments and conservation were specifically sourced from internationally recognized academic publications, electronic data sources and other educational websites. Further, the consulted journal articles and other empirical reference sources for the entire thesis range from the year 2010 to 2020.

The theoretical framework adopted for this study (the Urban Green Sustainability Theory) guided the researcher in the selection of literature for this chapter and other

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Olatoye, T.A.; Kalumba, A.M; Mazinyo, S.P (2019): Exploratory Review of Urban Expansion, Coastal Vegetation Environments (CVEs) and Sustainability Paradox. Being a paper published in the *Journal of Human Ecology, India.* REF NO: JHE-041-19/3152. 67(1-3): 21-30 (2019) J Hum Ecol, 67(1-3): 21-30 (2019) far-reaching concerns related to the research problem of this study. This chapter discussed the ecological benefits of CVEs, relevant empirical and theoretical literature on the different types of ecosystems, ecosystems services, the impact of human interference on coastal vegetation environments, land use change, urban expansion, coastal vegetation environments and conservation.

2.2 ECOLOGICAL BENEFITS OF COASTAL VEGETATION ENVIRONMENTS (CVEs)

According to Zhao, (2016), Coastal Vegetation Environments (CVEs) refer to environments that are characterized by the ecological interactions of land, vegetation and the oceans. They are exceptional areas where the vegetal marine and terrestrial climes spatially impact one other. According to Donato, (2011) Gardner, (2010); Hosonuma, (2010); Olatoye, (2011); Bradshaw, (2012); Dalponte, (2013); Green, (2013); Olatoye, (2013); Olatoye, (2014); Adam, (2014); Alfaro, (2014); Kalu, (2014); Dian, (2015); Aheto, (2016), Olatoye, (2019), Olatoye, (2020), the ecological benefits accruing from Coastal Vegetation Environments (CVEs) include the following.

(i) Photosynthesis: This is a procedure that involves the interaction of the biotic (plants) and abiotic (such as water and carbon dioxide) constituents of the environment for the improvement, distribution and continued existence of all living organisms. Plants are also the only living components of the biosphere that have the functional capability of transforming and utilizing carbon dioxide into usable forms such as chemical energy or starch (Adam, 2014). Also, photosynthesis plays important roles among others:

(a.) It restocks the supply of atmospheric oxygen, which could otherwise be rapidly exhausted by respiration processes of organisms and by burning substances (Kalu, 2014; Olatoye, 2019).

(b.) It is the only process that can utilize the enormous energy supply from the sun, and is therefore very essential in food cycles (Bradshaw, 2012).

(c.) It synthesizes other food elements such as proteins, vitamins, fats and oils (Alfaro, 2014).

(d.) It ultimately ensures the continued survival of the biosphere through the supply of energy requirements for all biotic components (Gardner, 2010). Unfortunately, the tremendous volumes of carbon dioxide in the atmosphere far outweighs the available vegetal resources required to carry out photosynthesis on account of inadequate self-regulatory mechanisms required by plants for the regulation of carbon dioxide concentration levels (Aheto, 2016).

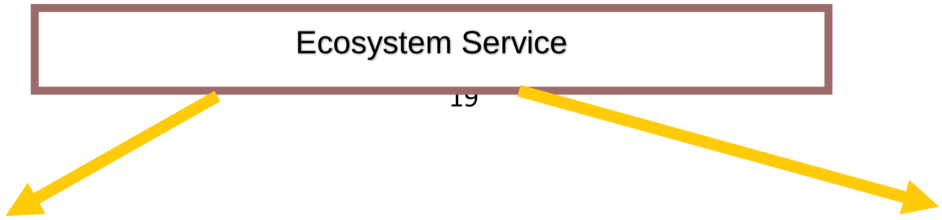
(ii.) Air Conditioning: According to Olatoye, (2019), the release of oxygen in the atmosphere during photosynthesis helps in environmental purification.

(iii.) Shelterbelts or Windbreaks: The establishment of shelterbelts and windbreaks have been established in CVEs so as to mitigate the effects of flooding and ameliorate the environmental conditions to conducive levels for biota conservation and growth (Dalponte, 2013). Vegetation protects the top soil and sustains soil fertility, in addition to inhibiting watershed disturbance by acting as barriers against soil or gully erosion (Olatoye, 2020). They also shelter buildings and other biotic components from natural phenomena such as intense heat from sunlight and windstorms (Green, 2013).

iv.) Coastal vegetation promotes hydrological and wildlife and conservation (Adam, 2014).

v.) According to Olatoye, (2014), coastal vegetation performs a very important function of atmospheric humidification, as well as ensuring the regulation of the earth’s weather and climate.

vi.) According to Dian, (2015), coastal vegetation is an essential ecosystem component which establishes a vital link in nutrients in addition to the absorption of inorganic components and integrating them into organic compounds in living tissues. The ecological and economic benefits of coastal ecosystem services are further illustrated with the cascade model as shown in Figure 1.



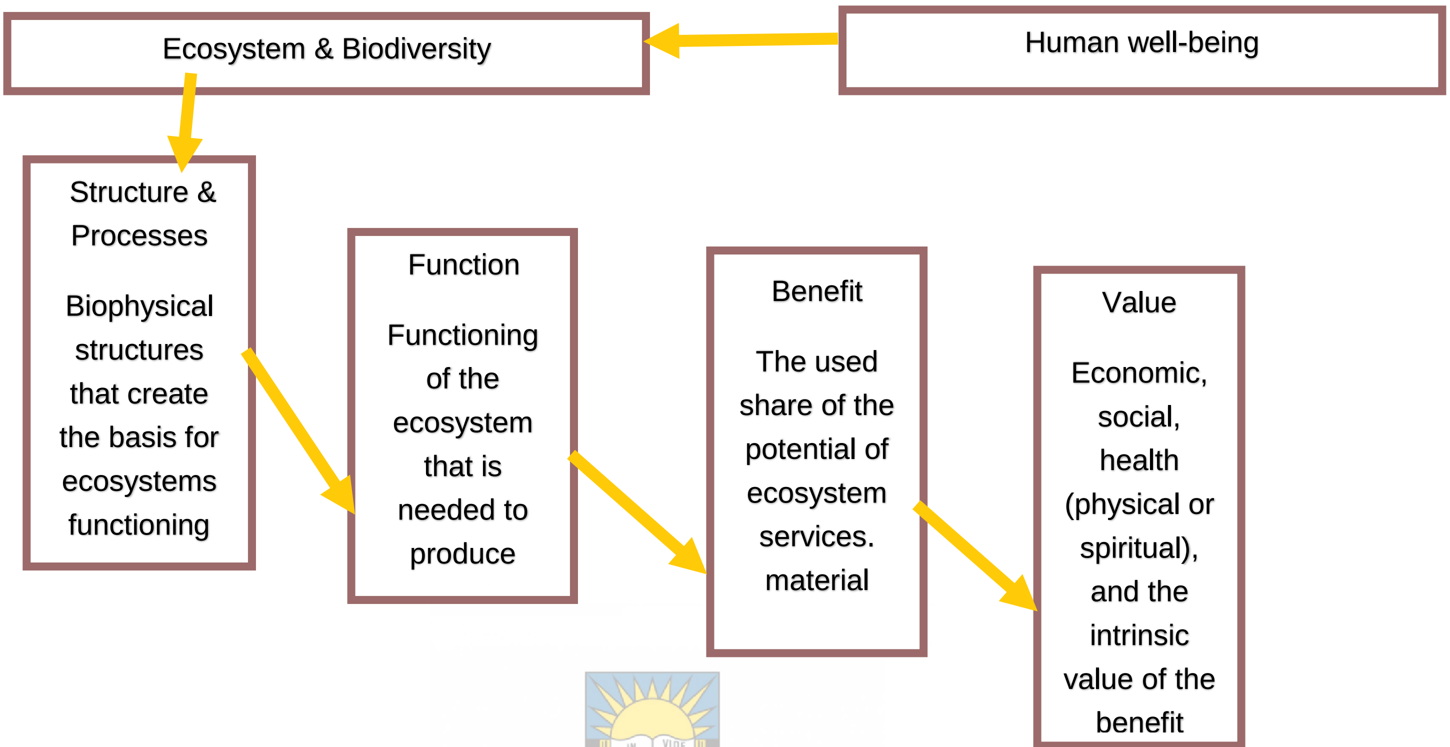


Figure 1: The Cascade Model With Integrated Indicators of Ecosystem Service (Source: La Notte, 2017).

Figure 1 depicts the cascade framework, which provides a linkage between natural systems to elements of human wellbeing, following a pattern similar to a production chain, from ecological structures and processes generated by ecosystems to the services and benefits eventually derived by humans (Nassl, 2015). The advantage of this framework is that it effectively communicates societal dependence on ecosystem services in key areas such as observations from a bio-centred or holistic approach, that is, biophysical structures and processes/functions belonging to the ecological sphere (Dian, 2015). Furthermore, the word function is generally used interchangeably in relation to ecological processes and ecosystem services (Hagen, 2010). Additionally, the cascade model explains the function and benefits of ecosystem services are generally defined as the ecosystem processes considered useful to humans (Haines-Young and Potschin, 2010). According to Nassl, (2015), the benefits accruable from ecosystems, as elucidated by the cascade model, include tangible natural resources derived from provisioning services (such as vegetation, crops, wood, water), or some regulating services (for example, clean water for multiple uses provided by water purification). Benefits, however, can also be intangible (such as recreation opportunities offered by nature).

2.3 CLASSIFICATION OF COASTAL ECOSYSTEMS

It is essential to classify ecosystems according to the extent of human interference they have received. Steenberg, (2015), provides the following classification of natural coastal ecosystems:

Unique Natural Coastal Ecosystems: These can be contextualized as intact coastal ecosystems in terms of species structure, quality, abundance, and diversity (Adam, 2014). They are core protected coastal areas specifically conserved to maintain the intactness of biodiversity and any species of special concern it may harbour. Also, Hagen, (2010) posited that human impact has not affected the structure of unique natural coastal systems since the industrial revolution. In many cases, unique natural systems are centers for research as well as for the practical understanding of biodiversity conservation in an environment of optimal ecosystem services functioning, although, climate change is excluded from the definition because human-induced climate change is likely to negatively affect all ecosystems (Tolvanen, 2016).

Semi-Natural or Modified Coastal Ecosystems: These are ecosystems characterized by human-induced interference but whose structural components are not humanly-manipulated (Adam, 2014). Examples of such ecosystems include natural forest regrowth used for the production of timber, or naturally regenerating pasture vegetation used for livestock production (Jana et al, 2016).

Sustainably cultivated Coastal systems: According to Braat, (2012), these are ecosystems typified with human impact is and many of whose structural components making up the ecosystem are cultivated in sustainable ways, and these include agroforestry, organic and bio-dynamic vegetation, and sustainable forestry.

Unsustainably cultivated Coastal systems: These category of ecosystems are characterized by greater human impact than that of any other species, and most of whose structural components are cultivated, with inputs of human-made capital such as coastal farmsteads, sown pasture, plantations, and so on (Farley, 2012).

Urban Coastal Systems: These ecosystems are typified by a preponderance of urban structures such as roads, buildings, dams, mines, railways, and other human constructions and erections, consisting of green spaces, parks, botanical gardens, horticultural greenhouses and lawns (Gomez-Baggethun, 2013). Most of the environmental factors in these systems (such as irrigation, drainage, temperature and nutrition) are controlled by human-made capital (Goble, 2014). Having embarked on a comprehensive classification of ecosystems, it behooves on the researcher to conceptualize urbanization and theories on land use change, because land use change, which results from the natural and anthropogenic interventions on the environment, is a central focus in this thesis. Hence, this is extensively discussed in the subsequent section of this chapter.

2.4 THE CONCEPTUALIZATION OF URBANIZATION

All over the world, it is found that rapid urbanization is a consequence of population growth. Shepherd, (2010); Zhou, (2011); Li, (2012); Chen, (2016); Guan, (2018) opined that the human population all over the world has rapidly increased from 5 billion in 1987 to 6 billion in 1999 and 7 billion in 2011. According to current projections, the global population will reach eight billion by 2024, and is likely to reach around nine billion by 2042, with over half of these population figures living around coastal environments (Deng, 2015). As part of this development, coastal cities in the developing economies have undergone rapid urban expansion (Singh, 2013) and this has resulted in tremendous pressure on land from both unintended and unrestrained alterations in land use/land cover (LULC) (Chandra, 2018). Additionally, undue pressure on ecological systems has resulted in urban sprawl in most metropolitan areas (Colantoni, 2016), contributing to environmental change on the global scene (Wu, 2013). Significant land use and land cover changes thus occur in coastal cities, with population rise projected to more than 32% between 2015 and 2030 (Birkmann, 2016). These coastal cities perform important logistic, production and governance roles within the communities and regions they are found in

(Roberts, 2014). It is also projected that coastal cities have a great impact on the future economic advancement of countries and larger geographic areas of the world (Roberts, 2014).

Various definitions have been provided for the definition of urbanization in literature. An urban area (such as a town, city, or metropolis) has been diversely defined by city administrators and academia in terms of population density, total population size, and built-up surface areas or structures (Wu, 2014). Also, Roberts, (2014), opined that the preponderance of built-up infrastructures, high population density, wide-ranging impervious surfaces, air pollution, altered conditions of climate and hydrology, as well as altered ecological system function and services permeate urban environments (Elmqvist, 2013). Nevertheless, it is impracticable to epitomize all the core features and components of urban areas into one definition. Basically, the two most important factors that satisfactorily defines urban areas are extensive built-up areas and a high human population (Sardosky, 2014). Fundamentally, these two factors directly or indirectly define the key ecological and environmental characteristics of urban systems (Wu, 2014). Urban coastal vegetation helps to regulate temperature, as well as providing natural filter and noise absorbing functions. CVEs also improve the aesthetic and physical quality of natural resources as well as micro-climatic conditions (Patarkalashvili, 2017), and promote improved quality of life of urban dwellers through the provision of several ecosystem goods and services, thereby enhancing physical, mental and social health, as well as improving the urban environment in general (Nesbitt, 2017). Despite these innumerable merits of CVEs, little has been done to protect this fragile ecosystem, hence, the need for constant monitoring of land use and land cover changes in CVEs (Chen, 2016; Zhao, 2017). If BCMM is to actualize the qualities defining a smart coastal city, the preponderance of illegal, unintended and arbitrary urban development to the detriment of natural coastal vegetation must be checked and the strategic development framework and integrated development plans have to be strictly implemented by the authorities and its stakeholders (Su, 2011; Gui, 2012; Li, 2012; Chen, 2019).

On account of population pressure around coastal cities, it is therefore imperative to conserve and safeguard coastal vegetation across the world, as well as ensuring that ecosystem services and biodiversity function at optimum levels (Maskell, 2013; Sandifer, 2015). Despite the declining state of the world's vegetation over the years (Aronson et al, 2014). Millions of poor people live on coastal vegetation resources, as well as sustaining the livelihood of almost 3,000 native cultures. According to the Food and Agricultural Organization (FAO, 2016), it is projected that over 2 billion people, (which accounts for over 40% of the population of developing countries) depend on fuelwood for domestic purposes. To this end, it is therefore imperative to provide substitute energy sources, as well as the need to monitor and conserve CVEs to ensure optimum ecosystem functioning and provisioning sustainability (Elmqvist, 2013). This will also ensure that the negative effects of urbanization are mitigated, in addition to reducing the harmful effects of climate change (Cabello, 2012; Chowdhury, 2016). Besides the conservation of biodiversity, other numerous environmental functions and services are derivable from CVEs (De Groot, 2010), these include reduced soil erosion, flood and desertification control (Imeson, 2012;

Miura, 2015), sequestration of carbon, water supply (Hopkinson, 2012) and beautification of CVEs (FAO, 2016). This research, therefore, makes a clarion call for continued research to be undertaken, in addition to consistent monitoring and conserving our fragile CVEs, to achieve optimum functioning and service delivery of CVEs (Richardson, 2010). From the foregoing, one of the ways of protecting of our fragile CVEs is by ensuring that urbanization is controlled and properly managed, hence the next sub-section elucidates on urban sustainability.

2.5 THE CONSEQUENCES OF URBAN COASTAL VEGETATION LAND COVER CHANGE

Sustainable land use can be defined as that which ensures the effective and efficient utilization of land to ensure optimal functioning of all components of the ecological system, such as vegetation, air, water, wildlife, and so on. In the same vein, Aheto, (2016) posited that urban coastal vegetation ensures environmental conservation by regulating surrounding wildlife habitat, soil, water, biodiversity, carbon fixing, in addition to offering other several natural resources in urban areas. From the foregoing, urban coastal vegetation land use change occurs due to the anthropogenic actions of man on coastal vegetation environments for different purposes such as urbanization, agriculture, mining and dam construction, which results in deforestation of vegetation, erosion and land degradation, climate change and global warming (refer to chapters six and seven). For example, Bradshaw, (2012); Chakravarty, (2012); Hosonuma, (2012); Green, (2013) disclosed that deforestation in tropical regions has been an ecological challenge affecting urban coastal vegetation communities. Also, the continuous dilapidation of the urban coastal vegetation environments portends major negative consequences on other sectors of the environment (Hosonuma, 2012), the manifestations of which have been noted to be in form of the rapid disappearance of vegetal cover leading to erosion, loss of biodiversity, soil degradation, and unfavourable hydrological changes. Regarding soil degradation, Goudie, (2018) also noted that the replacement of mature urban coastal vegetation by plantations of exotics has negative effects on the soil. Once CVEs are disturbed, the organic content of the areas they are found declines until the restoration of urban coastal vegetation is expedited, consequently contributing carbon to the soil as rapidly as it is lost through oxidation. However, high population density has led to a situation in which the land cleared from forest, is re-cultivated at repeated intervals and not allowed to regenerate into mature secondary vegetation (Teegalapalli, 2016).

Generally, it has been noted that land degradation is both a part and consequence of environmental changes leading to the loss of valuable land resources (Blaikie, 2015). Therefore, there is a need to strike an equilibrium in the uses to which the land is put in order to minimize the far-reaching ecological effects of coastal vegetation land use change (Wasige, 2013). The ecological problems associated with coastal vegetation land use change are linked with the socio-economic changes of the local population as well as population growth (Lambin, 2010). The findings of this study, therefore, highlight the need for a comprehensive assessment of human activities and the adaptation of sustainable environmental management practices such as close supervision of CVEs in the municipality and making more arable lands available through the restoration of already degraded and impoverished lands (Butt, 2015). It is on this premise that the perceptions of some scholars (such as Chan, 2011; Trincsi, 2017) on the schools of thought on urban coastal vegetation land cover change are discussed in the next sub-section.

2.6 SCHOOLS OF THOUGHT ON URBAN COASTAL VEGETATION LAND COVER CHANGE

According to Chann, (2011), there are several competing schools of thought on urban coastal vegetation land cover change, and as Trincsi, (2017) stated, these schools of thought linger stimulate academic debates within the academic world, as well the general public. The first school of thought suggests that vegetation conservation is an inevitable part of economic development (Wu, 2013). Also, there has often been a popular connection between deforestation, poverty occurrence and high population in urban areas (Chakravarty, (2012). This assertion is further buttressed by Blaikie, (2015), who opined that population pressure and poverty have resulted in massive deforestation of coastal vegetation resources in tropical countries. In Laos and Cambodia, for instance, governments have justified highland relocation schemes under the rhetoric of reducing what is considered unsustainable slash-and-burn agriculture (Hosonuma, 2012). Some sectors within civil society, most notably conservation NGOs such as the World Wildlife Fund (WWF) and WildAID have also subscribed to this thinking, investing extensively in programmes aimed at regulating and preventing local users from exploiting natural resources in areas of high biodiversity (Cox, 2011; Kowarik, 2011; Bull, 2013; Lefcheck, 2015; Landis, 2017).

The second school of thought on urban coastal vegetation land cover change is that the dependence of urban communities on natural resources is the key to conservation and sustainable natural resource management (Gruber, 2010). It asserts that top-down large-scale development initiatives, both state and private, interfere with local communities' ability to sustainably manage natural resources (Doppelt, 2017). These polarised perspectives dominate the mainstream discussions on coastal vegetation land cover in Asian countries, and as such have had a profound influence on natural resource management strategies. At this juncture, it is pertinent to state that the opposing assertions described here are reconcilable. Several techniques are utilized in the evaluation and assessment of global landcover change. From the foregoing, the next section is focused on remote sensing applications in urban coastal land cover change detection.

2.7 REMOTE SENSING APPLICATIONS IN URBAN COASTAL LAND COVER CHANGE DETECTION

Chen, (2012) disclosed that urban coastal land cover change detection denotes the procedure for ascertaining differences in urban coastal landscapes by investigating them at different periods of time. This procedure can be expedited through manual methods or automated techniques relating to the utilization of remote sensing (RS) and GIS software. According to Lillesand (2014), the manual methods adopted in the course of deducing urban coastal land cover changes from remotely-sensed satellite imageries or aerial photos requires the analyst or observer to delineate areas of concentration and relating the same between imageries from two or more different periods of time. Also, Zou, (2019) stated that in the course of interpreting

RS imageries, a stereoscope can be utilized, as this makes provision for two or more spatially overlaid imageries to be presented in 3D, thereby enhancing the interpretation of RS imageries. The manual methods of interpreting RS imageries is well appreciated when investigating change between distinct and separate vegetation land cover categories (such as coastal vegetation land use and land cover maps) or when vegetation land cover changes are highly significant such as massive deforestation across territorial boundaries (Zhu, 2016). Additionally, Cabello, (2012) opined that the significance of manual methods of interpreting vegetation land cover changes in RS imageries from different sources cannot be over-emphasized, examples include the comparison of historic RS satellite imageries to present-day ones. On the other hand, there are two types of investigating urban coastal vegetation land cover changes through automated methods namely: Post-classification urban coastal LULC change detection as well as image differentiation with the utilization of band ratios (Hussain, 2013). Post-classification urban coastal vegetation land cover change detection involves the classification or categorization of RS satellite imageries from specific time periods using the same classification pattern into several discrete categorizations, such as urban coastal vegetation land cover types (Blashcke, 2010). Image differentiation, on the other hand, involves the technique for generating band ratios such as the Normalized Difference Built-Up Index (NDBI); as performed in Chapter seven) from individual urban coastal LULC satellite imageries. Consequently, the difference in band ratios is determined between the different periods of time (Thenkabail, 2016).

Schneider, (2012) presented the issues in change detection methods, by looking at the numerous algorithms that have been developed: multi-date composite image change detection (Kavzoglu, 2016), image change algebra detection, image regression, manual on-screen digitization of change (Dewan, 2012) or post-classification comparison detection (Foddy, 2012). Different methods introducing fuzzy logic, neural networks (Rojas, 2013) or knowledge-based vision systems have also been tested to examine the likelihood of changes detected from remotely sensed data (Chen, 2015).

2.7.1 Issues to Consider in Change Detection Studies

Some of the issues to consider in change detection include image geo-referencing, image resolution and visual inspection, as well as pre and post-classification change detection, which are discussed below.

Image Geo-Referencing

According to Comber, (2012); Immitzer, (2016), the art of geo-referencing involves the precise positioning of an image to its actual longitudinal and latitudinal location on the ground. In the eventuality of spatial offsets emanating from the positioning of remote sensors, inadequate Digital Elevation Model (DEM), or relief displacement, the individual pixels denoting specific phenomena on the landscape will not overlap in the imageries being studied, thereby concomitantly leading to erroneous results (Dalponte, 2016). Hence, the extent to which this negatively influences the reliability of the results will be hinged on the magnitude of the geo-referencing errors when investigated in comparison to the phenomena been studied (Eastman, 2013; Houburg, 2015).

Image Resolution

According to Li, (2011), there should be similarity amongst all types of RS satellite image resolution in the individual imageries to be compared. In the same vein, it is advisable to use two images acquired from the same RS satellite, so as to have similar spatial, spectral, and radiometric resolutions accordingly. With reference to temporal resolution; it is appropriate that the two scenes of remotely-sensed data to be compared are derived from similar sunlight angular inclinations and time periods, as this will concomitantly reduce errors associated with incident light, shadows, as well as the amount of foliage (El-Kawy, 2011; Giri, 2012).

Visual Inspection

It is discovered in literature, (such as Campbell, 2011) that the change detection begins with the visual comparison of co-registered RS satellite images from two different periods of time, even if the main research motive is to utilize automated algorithm techniques for LULC change detection and/or classification. It is on this consideration that most GIS/RS image processing software incorporates tools to carry out overlay functions, in-depth/detailed observation, as well as side-by-side viewing of imageries (Blaschke, 2014). In some cases, manual digitizing methods may be adopted in the course of identifying and classifying LULC changes, as well as in speeding up the most appropriate automated LULC change detection technique to be utilized for any related study (Atkinson, 2012).

Pre-Classification Change Detection

According to Avelar, (2014), pre-classification LULC change detection incorporates the art of simply subtracting the pixel value in one image from the pixel value of the second image from the same geographical location. This technique is performed within the GIS software environment, and it is both conceptually and computationally simple and fast (Mbolambi, 2016). RS satellite imageries incorporate several individual co-registered bands of colours (Dewan, 2012). According to Guo, (2019), it is expedient to state that a multispectral digital camera has four (4) bands, and these include: near-IR, green, blue and red (Reece, 2019). Additionally, the process of band differencing can only be adopted to one band per time, and it is a herculean task to distinguish or tell apart different LULC features on the composite image based on the “color” that is seen (Guha, 2018). In addition, each of the spectral bands contains atmospheric effects, hence, it is imperative to correct atmospheric errors from one RS image to another (Steffen, 2010).

Post-Classification (Thematic) Land Cover Change Detection

According to Vittek, (2014) and Zou, (2019), post-classification land cover change detection involves the procedure for generating two independent thematic rasters with the aid of the supervised method of image classification. Thereafter, the change detection procedure is then applied by comparing the before classes and after classes in each pixel. With higher input classes, the results become easier to interpret visually, and GIS tools can be utilized in quick simplification of results for presentation to policy makers and decision makers. As put forward by Kpienbaareh, (2018), it is important to state that thematic, or post-classification, change detection results are characteristically of low accuracy on account that the accuracy of results is hinged on the correctness of the input classification data. In the course of analyzing change detection in vegetation studies, certain classification approaches must be adopted (Rawat, 2015).

Several scholars (such as Hansen, 2013; Kavzoglu, 2016; Kpienbaareh, 2018) have opined that image classification utilizes the spectral information contained within image spectral bands by categorizing pixels into various classes. According to Li, (2018), the most commonly utilized applications of supervised classification procedures include the maximum likelihood (MLC), and minimum distance classifiers, and the duo are utilized with multispectral and hyperspectral data sets correspondingly. MLC utilizes randomly selected training data to compute the probability of a specified pixel by approximating the mean and variance and then assigning the pixel to the envisaged class that seems most likely appropriate (Pu, 2012). Further, the MLC procedure computes or calculates the probability on the premise that the data are evenly distributed. Hence, urban coastal vegetation land cover mapping using RS images yield more valid and reliable results through the utilization of supervised classification technique in classifying pixels of known and unknown identity through unsupervised methods of classification (Cabello, 2012; Klemas, 2013). In addition, supervised classification employs manual means in identifying the training areas that are a representation of the desired classification categories/classes (Selvam, 2012). Furthermore, it is imperative to randomly select suitable training areas and hitherto instruct the classifier to detect and distinguish the different land cover classes (Zhu, 2016). Classification methods utilized in vegetative LULC mapping include pixel and object-based classifications, and vegetation indices.

Pixel-Based Classification (PBC)

According to Liu (2010), PBC is a conventional process of classification based on categorizing individual pixels with the adoption of supervised and unsupervised classification procedures. However, it is expedient to state (as postulated by Rapinel, 2014; Zou, 2019), that traditional PBCs based on spectral dissimilarities are an inappropriate approach for differentiating vegetation land cover types with similar spectral resolution characteristics.

Object-Based Classification (OBC)

According to Fensholt, (2012); Kavzoglu, (2016), OBC is a traditional method which involves the categorization of spectrally-homogenous pixels through the process of Image Segmentation (IS) and thereafter grouping the individual LULC phenomena being studied (Liu, 2010; Campbell, 2011). The operationalization of the OBC technique is possible sequel to the derived information from an array of similar pixels/ objects in the RS imagery. On the other hand, IS permits the use of additional attributes or features such as the shape, colour, size, texture and contextual information of the land cover image when analysing the image attributes. According to Kavzoglu, (2016), the performance of the OBC procedure is determined by the quality and accuracy of the image segments and the segmentation process. The OBC approach has advantages over the PBC approach in two major ways. Firstly, minimization of salt-and-pepper effects as well as the reduction in “within-class” spectral variation is a characteristic feature when changing the classification units from pixel format to image objects in the PBC approach (Weih, 2010). Secondly, a large array of attributes distinguishing the object’s spatial, textural and contextual characteristics greatly enhances the direct spectral observations of the RS imagery, and this concomitantly advances the accuracy and veracity of results derived from classification. Several studies have adopted the OBC technique in various investigations involving vegetation monitoring as well as in terrestrial and coastal LULC change detection studies (Lück-Vogel, 2013; Cho, 2015). In a study conducted by Lück-Vogel, (2013), his research involved the adoption of the OBC approach in the evaluation of natural vegetation health and intactness, using segmented multispectral RS satellite imagery. From the foregoing, the OBC procedure utilized derived information regarding the structural (compactness), textural (NIR standard deviation) as well as spectral (brightness) of the LULC attributes of the study area, and the procedure yielded reliable results with an overall accuracy of 80% using Landsat TM imageries and 90 to 95% accuracy for the SPOT 5 imageries. Hence, it is on this premise that Lück-Vogel, (2013) made a clarion call in favour of the OBC technique in LULC studies, which could be enhanced by the respective LULC attributes. It is also germane to note that both techniques have their peculiar limitations, for instance, the limitations associated with OBC technique include errors that occur in the course of carrying out segmentation process, and these errors can either be due to under-segmentation or over-segmentation (Hussain, 2013). On the other hand, the errors associated with the PBC technique occur during the “within-class” spectral variation, the salt-and -pepper effect, as well as errors emanating from mixed pixels (Liu, 2010). Other methods used in vegetation LULC classification include the hybrid procedure, and as the name implies, it involves the integration of both the OBC and PBC procedures, and this procedure was adopted in mapping the coastal vegetation LULC of the French Atlantic coastline (Rapinel, 2014).

Normalized Difference Vegetation Index (NDVI)

According to Singh, (2016) and Kpienbaareh, (2018), Normalized Difference Vegetation Index (NDVI) is a classification technique, which has been widely operationalized in several ecological studies, for assessing, gauging, quantifying as well as computing biomass and vegetative energy through the integration of two or more spectral bands (Campbell 2011). Studies such as that of Petach, (2014) have evaluated the quantity of reflected sunlight intensity from the earth and photosynthetic capacity of vegetation land cover. Consequently, the interpretation of findings according to Van, (2015), states that the vegetal cover in a pixel is if there are higher levels of reflected radiation in near infrared (NIR) wavelength than those recorded in the visible wavelengths. On the other hand, there will be sparse vegetal LULC (such as grassland, tundra or desert) if the rate of radiation in the NIR is slightly more than that of the reflected visible wavelength. According to Holme, (2014), this is a reliable assertion, because the high chlorophyll content, which characterizes robust/dense vegetation, absorbs light that is more visible and this consequently results in greater reflectance of NIR energy, while a reverse scenario occurs in sparse vegetation, which reflects lesser quantities of NIR, which depicts unhealthy mesophyllic leaf structure, and poor vegetal LULC. Rouse et al. in the

Texas University Centre initially adopted NDVI as a procedure in vegetation biomass mapping in 1973 for Remote Sensing. Pettorelli, (2014) elucidates the importance of NDVI in ecological and vegetation conservation mapping. It serves as a dependable correlative index in the assessment of vegetal energy as well as the functionality of varied ecological systems (Reif, 2017). As opined by Mbolambi, (2016), NDVI values vary from -1.0 to 1.0, and this means that values less than zero typify the absence of vegetal cover, while figures that are beyond 0.5 depict dense/robust vegetal LULC (Wang, 2010; Sinha, 2015).

2.8 THE GLOBAL IMPACT OF URBAN EXPANSION ON CVEs

Although over half of the world's human population reside in coastal urban areas (Aronson, 2014; Bagan, 2014), the global impact of urban coastal expansion, population growth and land consumption in metropolises and cities all over the is very alarming, and this has resulted in the escalation of pressures on vital ecosystem functions (Liu, 2015). On the African scene, urban growth is estimated at 3.7 percent a year, which is more than twice the world's urban growth rate (UN-Habitat 2010). In the same vein, Turok, (2012) forecasts that between the year 2010 and 2050, African urban populations will increase by about 1.2 billion additional inhabitants. Consequently, urban explosion results in changes in the quality of ecological conditions, and ultimately affecting people's health and well-being (Dlani, 2015). From the foregoing, the impact of urbanization on CVEs has been documented in the growing literature, which shows consistent and significant changes in urban coastal vegetation species richness and composition (Slemp, 2012). With the worldwide land cover change, biogeochemical cycles, hydrologic systems, and climate and biodiversity change driven by urbanization, increasing numbers of ecologists have accepted that urban areas are hot spots that drive environmental change on multiple scales (Liu, 2015). These hot spots are estimated not only to be current threats for ecosystems but also will probably last for a long period in developing nations. The global urban population will reach 5 billion by 2030 and will increase by 2.7 billion, nearly doubling today's urban population of 3.4 billion by 2050, which indicates that the dramatic urbanization phenomenon will continue (Liu, 2015). Consequently, as epitomized in existing literature (such as Burt, 2014; Moyo, 2014; Spalding, 2014; Carley, 2017; Oldeman, 2017), population pressure results in the degradation of coastal vegetation environments, thereby affecting both the poor and advanced economies of the world, however, the developing nations are mostly affected through excessive logging of marketable coastal vegetation species, reducing labor productivity, exacerbating economic and social crisis, and ultimately increasing poverty (Le, 2014), since more than one-third of the populations of people that live in developing countries depend heavily upon nature to provide them with resources to live (Tietenberg, 2016).

In third world countries, unauthorized logging is a highly preponderant activity among low-incomed people (Chakravarty, 2011), an environmental problem which has reached abysmal levels in many developing countries, because it destroys natural habitats and ecosystems functioning (Rands, 2010). The aftermath of this, as posited by Guillebaud, (2014) is that developing nations do not have the resources to help their citizens find alternative sources for survival. Also, weak legislations, high corruption (Ehwariame, 2018), unplanned urban expansion and development (Le, 2014), high unemployment rates, conflicting demands between conservation and societal upliftment (Davies, 2013; Cochard, 2017) are all a precursors to coastal vegetation degradation (Kibria, 2011). Developed nations on the other hand have enormous resources which are better managed (Chakravarty, 2011; Stewart; 2012), but degrade their coastal vegetation on account of urban expansion (Temu, 2016).

According to Masterson, (2014) the forces of industrialization continue to have negative consequences on existing CVEs, as the natural world is not designed to handle the concentrations of such things without negative consequences, and those consequences are quite easily being measured as a loss of biodiversity (Sandifer, 2015). In general, it is opined that all that makes the earth a more humanly habitable environment are observed to paradoxically make it a less biodiverse place (Sandifer, 2015). From the foregoing, urbanization is a major consequence of population pressure in developed and developing nations of the world, South Africa inclusive (Cobbinah, 2015). In the United States there is a direct relationship between losses in coastal vegetation and increases in cropland (Dobson, 2010). Internationally, there is half a hectare of coastal vegetation disappearing to other land uses every second (Chakravarty, 2011; Pendleton, 2012). One of the potential dangers of decreasing the amount of endangered natural habitats is that species will no longer be present on earth (Sandifer, 2015), and the coastal fragile ecosystems will be the worst hit (National Geographic, 2010; WWF, 2017). Consequently, these countries have suffered from coastal vegetation and other species losses over the years (Chakravarty, 2011; WWF, 2017). With more than half of the world's population now living in developed countries of the world, urban expansion has led to the disappearance of many habitats (Population Action International, 2011), resulting in increased consumption rates, as well as the demand for food and energy, thereby increasing pressures on ecosystems (McKinsey, 2011; United Nations World Economic and Social Survey, 2013; Edet, 2014). With the majority of population growth occurring in urban areas, the concomitant effect is compounded pressure on biodiversity (Edet, 2014). Other activities associated with urbanization, such as infrastructure and industrial developments, are also important contributors to habitat loss (Population Action International, 2012) and ultimately ecosystem degradation (LEDDRA, 2010).

According to Keenelyside, (2012), the constant monitoring, conservation of coastal vegetation changes and promotion of urban greening is a sine-qua-non requirement in restoring our fragile coastal vegetation ecosystems. It is also widely argued that educating individuals in developing countries about the need to preserve biodiversity is a must for ensuring human survival (Beatley, 2014; Soulé, 2014; Romanelli, 2015). Additionally, it is imperattive to educate locals on the impact people are making on the environment and orientating them with how they can live in equilibrium with nature, so as to preserve biodiversity without causing further oppression (UNESCO, 2016; Baus, 2017). Many times, dwellers within the coastal vegetation areas in developing countries do not realize that there are alternative ways of making ends meet than to put the environment into jeopardy (Oyedepo, 2012). In addition, empowering of women and population have been some of the suggested strategies to curb coastal vegetation degradation (Engelman, 2016;

Australian Academy of Science, 2018). Threat to changes in biodiversity with an increase in global urbanization is a concern that needs to be brought to the foreground. Hence, it is essential to discuss the consequences of urban expansion on South Africa's CVEs, as elucidated in the next sub-section.

2.9 CONSEQUENCES OF URBAN EXPANSION ON SOUTH AFRICA'S CVEs

In terms of urbanization, South Africa has had a turbulent history which is marked by the implementation of irregular spatial policies which resulted in unbalanced spatial development and further broadened spatial inequalities (Turok, 2012). Consequently, this has exacerbated the misalignment between urban development, population growth as well as vegetation and biodiversity conservation (Mahlanza, 2014). One of the reasons for the misalignment is that people have continued to move towards the metropolises and cities (BCMM inclusive). This has been necessitated by the search for employment opportunities, better living conditions or better-quality public service delivery, which are inexistent in the rural areas (Turok, 2012). Consequently, a series of urban environmental apprehensions results on account of uncontrolled urban expansion, and these include deforestation/vegetal loss, urban heat, water and energy shortages, overloaded sewage treatment services and pollution (Halleux, 2012). Furthermore, South Africans have migrated to the cities in large numbers because of the difficulty to obtain their means of livelihood (Turok, 2012). This has further culminated in intense pressure on the functioning and services of ecosystems and biodiversity in general (Cocks, 2016).

Urban development usually gives rise to a dramatic change of the earth's surface, resulting in the spatial growth through the provision of basic amenities, improving accessibility to inaccessible communities, improvement of national economies, and the development of cities to metropolitan areas (such as BCMM). In spite of all these positive developments associated with urban development, it has its demerits, chief of which are population explosion and land degradation, for example, Weng, (2011) opined that urban expansion has led to the removal of natural vegetation and replaced by non-evaporating and non-transpiring surfaces such as metal, asphalt and concrete. Furthermore, the human population residing in urban areas reached 50% as a result of rapid urban growth in developing countries (Swetnam, 2011). Furthermore, urban expansion has greatly reduced the country's enormous valuable urban coastal vegetation resources, which are valued for their medicinal and local uses, biological diversity, as well as its spiritual and aesthetic values (Turok, 2012; South Africa Environment Outlook, 2015). The Millennium Ecosystem Assessment, (2011) ranks South Africa as the third richest in terms of biodiversity in the world, for example, the woodlands serve as the most extensive forest resources of the country, originally accounting for about 42 million hectares of open savannah, of which as little as about 22 million hectares now remains (Marchese, 2015). Also, there exist about 1.5 million hectares of total landmass (FAO, 2014), which provide employment to multi-billion rand industries, as well as contributing 27.4% to the country's agricultural Gross Domestic Product (Zokwana, 2013). Unfortunately, the South African CVEs have largely become fragile and highly endangered on account of anthropogenic factors, chief of which is an urban expansion (Turok, 2012). It is on this premise therefore that it is imperative to ensure the sustainability of urban expansion vis-a-vis conservation of CVEs in the South African space, and these are elucidated in subsequent sub-headings. Additionally, South Africa's coastal urban resources are under considerable threat and are already severely degraded in many areas due to unsustainable development (DESA-UN, 2013) which warrants the research to be conducted. Unless they begin to be managed sustainably, these resources will be lost for good (Kimmins, 2011; Poore, 2013). This will make it very difficult to actualize the much-needed economic growth and meet basic needs in a sustainable manner, especially that the South Africa economy is dependent on natural resources (Cilliers, 2014; Cole, 2014; Du Plessis, 2014; du Toit, 2015; Cocks, 2016).

There is an urgent demand for scientific research to provide ecological solutions for problems related to urbanization, degradation of freshwater, and movement of materials between ecosystems (Palmer, 2014). Furthermore, the concomitant effect of urbanization on CVEs was elucidated by Wu, (2014), when he affirmed that the process of urban expansion is accelerating and has potentially large influences on landscape and ecosystem function in coastal cities and surrounding areas. Further, the conversion of South Africa’s coastal vegetation land use types to urban uses is one of the most visible changes that result from urban expansion, as coastal vegetation loss may conflict with the government’s developmental goals, especially if urban areas expand through a low density, or sprawling type of development onto CVEs. As Turok, (2012) posited, urban expansion rates exceed the human population growth rate in South Africa, thereby suggesting that South African cities are becoming more expansive rather than more compact, and ultimately resulting in potentially greater loss of productive land and greater risk to food security, than may be needed for a given level of economic development. Hence, the challenge associated with South Africa's urban expansion is further illustrated in the Figure 2.

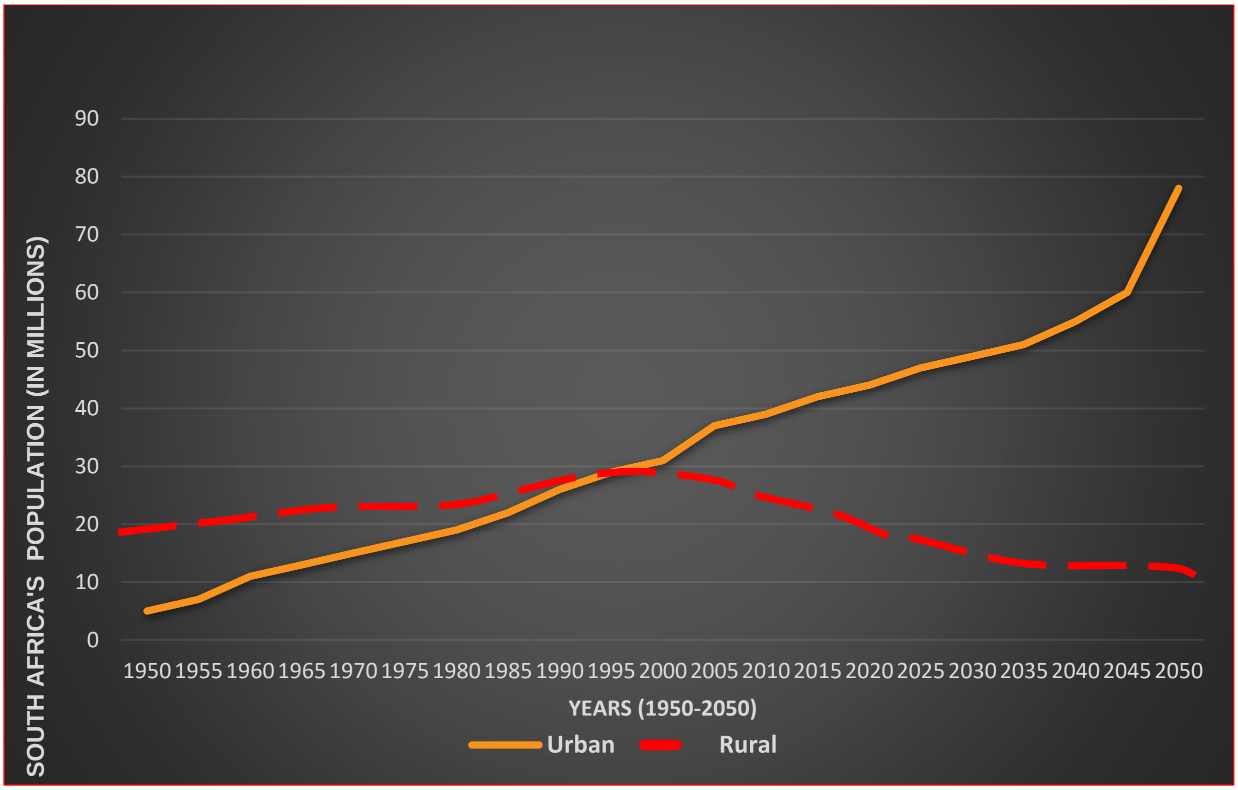


Figure 2: South Africa's Population Growth from 1950-2050 (Turok, 2012)

Figure 2 depicts the past, present and projected rate of urban and rural growth in South Africa from the year 1950 to 2050. The figure depicts an accelerated pace in urban population growth, during the 1980s after many of the restraining policies of the apartheid regime proved difficult to implement. Figure 2 reveals that the average annual growth rate of urban population growth increased in the 1970s and the early 1990s, and this scenario concomitantly culminates in urban expansion. South Africa's rural-urban transition started in the course of this period, with a preponderance of the population residing in the metropolises, cities and big towns (the brown line), and the population has continued to increase since then (chapters six and seven for further explanations from field results conducted in this study). The major cause for South Africa's urban expansion is similar to that in most parts of the world, such as the uneven distribution of wealth and economic prospects in the country, as the metropolises and big cities have steadily outperformed the other parts of the country in terms of economic growth and employment opportunities on account of their higher productivity levels and their efficiency in the production of goods and services. Further, this is a reflection of the merits of 'economies of agglomeration' that is accruable on account of enormous concentrations of economic activity, such as matching trade and economic requirements for labour, sharing of economic infrastructure, information and services; as well as mutual cooperation amongst industrial establishments and other economic institutions (Storper, 2010), the big cities are also a haven for corporate businesses, high-order public services, such as departments at both provincial and national governmental levels, higher education institutions, specialized health facilities/services as well as manufacturing (Turok, 2012). Further, the big cities have also been home to many South African foreign direct investment initiatives such as the manufacturing of automobiles. Figure 3 shows the contribution of different places to South Africa's total economic output. It is also imperative to state that BCMM is among the five metros that dominate the South African economy, accounting for about 52 % of total economic activity (OECD, 2011). Studies have been conducted on urban expansion, associated land use changes and their complex effects on ecosystems. In relation to urbanization trends vis-à-vis ecological conservation at BCMM, Pakati, (2018), emphasized that to have balanced environmental conservation and economic development through the spatial transformation and integration of BCMM into catalytic urban development programme areas, and these include the revitalization of East London CBD and environs, the transformation of the MELD (Mdantsane East London Development) corridor, the revitalization of the Mdantsane Urban Hub and Bhisho – King Williams Town Corridor. It is therefore imperative to state that urban development plans will immensely contribute to the economic development of BCMM on one hand, thereby posing challenges on biodiversity conservation in the metro on the other.

2.10 BCMM ECOLOGICAL ENVIRONMENT STATUS

The BCMM is represented by a diverse range of ecosystems, ranging from coastal vegetation, forest, dunes, afromontane hills, subtropical thicket, wetlands, and riverine ecosystems (Buffalo City Municipality, 2015). Furthermore, the BCMM is listed as a global biodiversity hotspot, and it is situated within the highly-diverse Albany centre species of endemism, along with the Maputoland and Pondoland centres of endemism further north (Hagen, 2010). The major biomes represented within the municipality include subtropical thicket, afromontane forest and savanna (Buffalo City Municipality, 2017. Many ecosystems within the BCMM are stressed and are in need of conservation and remedial attention (BCMM Report, 2017). Many terrestrial ecosystems have become infested with invasive alien vegetation, while many freshwater and marine ecosystems are subjected to high levels of pollution (Buffalo City Municipality, 2015). Certain species are, however, in decline due to direct factors such as over-harvesting. Based on the BCMM State of Environment Report (2016), the major threats to biodiversity within BCMM are categorized below:

TABLE 1: THREATS TO BIODIVERSITY IN BCMM

Biodiversity Threat Category	Biodiversity Threat Subcategory
Urbanization impacts	Low income housing developments, Encroachment into public open spaces, Illegal dumping, Land use changes Failure to rehabilitate disturbed areas, Habitat fragmentation. Legal and illegal stone and sand mining, Poor water quality.
Over-utilization impacts	Removal of trees for fuel wood and furniture Collection of medicinal and culturally important plants
Cultivation and agricultural impacts	Agriculture and forestry Overgrazing by domestic livestock Spread of alien invasive species

As depicted in Table 1, failure to rehabilitate disturbed areas on the part of government and city administrators have led to environmental degradation, reduction in scenic beauty, as well as erosion problems in such areas. The table further depicts the threatening phenomena to the conservation of biodiversity of the study area, which includes impacts from urbanization, over-utilization, as well as agricultural/ cultivation impacts. From the foregoing, Table 1 reveals that the impact of urbanization in BCMM include the establishment of low-income housing developments. Also, former open spaces in the study area have given way to urbanization (through the construction of roads, public buildings and other infrastructure) in areas such as East London, Mdantsane, Schornville, and Zwelitsha, just to mention a few (refer to chapters six and seven). Other problems resulting from urbanization include stone and sand mining as well as poor water quality conditions. Further, there is a preponderance of both exotic and indigenous tree plantations (that were established during the apartheid era) for furniture and fuelwood, examples include *Tectona grandis, Gmelina arborea*, *Pinus caribaea*, among others. In the same vein, the study area has witnessed the harvesting of medicinal and culturally important plants such as *Hypoxis hererocallidea*, *Strychonos henningsii*, *Rumex lanceolatus*, *Ozoroa mucro nata Acacia karoo, Cotyledon orbiculata* , and so on (Wintola, 2015). In addition, as stated by the South African Cities Network (2016), there is no clear vision for the city's CBD and no agreement to establish a city improvement district, coupled with strong decentralisation of businesses from the CBD. Also, the BCMM wetland Report (2017), stated that the key threats to the vegetative wetlands located within BCMM include: development within and around vegetative wetlands, pollution and excess nutrients, erosion, over grazing/tramping, invasive alien plants (IAPs), draining of water, as well as lack of buffer zones next to wetlands.

2.11 THE QUEST FOR AN OPTIMUM COASTAL VEGETATION CONSERVATION AND URBAN SUSTAINABILITY

The sustainability of urban development refers to a process, which ensures the development of societies, as well as the exploitation of resources in a sustainable manner, without compromising the opportunities of future generations to utilize these resources. (Wu, 2014). As also indicated by (WCED, 2011), sustainable development is a process of ensuring that the utilization of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations. Urban sustainability may refer to a set of dynamic conditions that satisfy the needs of current and future generations in an urban area, but it is more profoundly an ongoing adaptive process of achieving and maintaining those conditions. Also, urban sustainability and urban resilience have been increasingly discussed together as complementary rather than contradictory terms (Wu, 2013). For the purpose of this study, urban sustainability is conceptualized as an adaptive process of expediting and preserving a virtuous cycle between ecosystem services and human well-being through combined ecological, economic, and social actions in response to changes within and beyond the urban landscape. Another concern is with the fiscal capacity of these economies to fund the considerable costs of urban infrastructure and avoid damaging bottlenecks, traffic congestion and polluted watercourses (World Bank, 2013). A third concern is with the capacity of urban labour markets to absorb a growing, low-skilled, youthful workforce, potentially resulting in the 'urbanization of poverty' (Turok, 2012). Intense competition for scarce jobs and incomes can strain the social fabric, fuel popular unrest and deter private investment (Saunders, 2010). In addition, expanding informal economies and informal forms of service provision tend to imply inferior social protection and greater vulnerability. These are among the greatest concerns of hard-pressed governments experiencing rapid urbanization, especially in Africa (Buckley, 2014; UN-Habitat, 2014). In light of this discussion, therefore, there is a need to ensure equilibrium/sustainability in urban expansion efforts on one hand, and the sustainability of CVEs on the other. Several literature on coastal ecological management suggests an evolving sustainability-centered paradigm. On the other hand, scientists (such as Gaston, 2010; Ramalho, 2012; Clark, 2013; Cumming, 2013) have proffered the need for optimum coastal vegetation conservation and urban sustainability. It is on this premise, that Wu, (2014) stressed that the concept of urban sustainability has become sine-qua-non as regards environmental development in the past few decades (Ahern, 2013; Jones, 2011; Lee, 2013; Potschin, 2013). In a bid to ensure a balance between urban development and conservation of endangered CVEs, Forman, (2014), suggested that geographers, city planners and ecologists should conceptualize urbanization from landscape development perspectives, while environmentalists, on the other hand, emphasize the need to conserve CVEs in a changing urbanized world (Standish, 2013), by providing a common foundation (the landscape), for ecologists, geographers, social scientists, planners, and engineers to optimally function together so as to optimize land use types so that nature and people can optimally and excellently flourish for long term. In agreement with this assertion, it has been further suggested in literature that in order to ensure optimum coastal vegetation conservation and urban sustainability, the importance of ecological system services to human well-being must be incorporated in current urban coastal ecological studies (Jenerette, 2011; Pickett, 2011; Jones, 2013; Potschin, 2013; Standish, 2013), thereby resulting in increasing multidisciplinary trends of urban ecology in terms of goals, through sustainability-oriented methods (from both natural and social sciences), stakeholders (ecologists, scientists, practitioners, decision-makers, and stakeholders of many kinds (Swaffield, 2013).

2.12 CONCLUSION

This chapter presented a review of the literature on urban expansion, coastal vegetation environments and conservation. Reviewed literature for this thesis is comprehensive, diverse and carefully chosen in accordance to pertinent themes in the particular field of research. Further, the review raises some vital concerns that can intensify intellectual deliberations in fields of ecology, controlled urban planning, environmental/coastal ecosystems management benefits and challenges. Other topics discussed include ecological benefits of CVEs, classification of urban coastal ecosystems, consequences of coastal urban land cover change, schools of thought on urban expansion as well as urban coastal change detection. Other topics include classification methods applied in vegetation mapping, the impact of urban expansion on CVEs, consequences of urban expansion on CVEs. The next chapter focuses on the research methodology adopted for this study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This study was devoted to the empirical authentication of the effects of urban expansion on coastal vegetation ecosystems conservation and functioning in Buffalo City Metropolitan Municipality, Eastern Cape Province, South Africa. This chapter conforms to the UGS Theory, firstly, because it helped the researcher to analyze the study objectives through the collection, processing and analysis of data, to achieve the overarching aim of this research. Secondly, the adopted research methods are aligned to the theory, because it guided the structural and scientific interpretation of the research design of this study, and enhanced evaluation of the Spatial Development Framework (SDF) and the Integrated Development Plans (IDPs) for the study area, as well as their future implications in ensuring sustainability CVEs in BCMM. In addition, it guided the assessment of ecosystems health, quality, resilience as well as providing scientific support to ecosystem services provision, and sustainability of the fragile BCMM CVEs in order to stimulate management efforts geared towards the protection of biodiversity conservation.

The methodological positioning implemented for collected data ensured legitimacy, veracity, integrity and generalizability of the research outcome for this study. The research methods also helped to analyze the total findings of this thesis. The plethora of research instruments adopted for this study includes the research design, procedure for data gathering, survey questionnaire and the sample. Others include the adopted strategies for data analysis (qualitative and quantitative), observation, and the reality and validity techniques, ethical considerations and conclusion. The use of the survey method by previous scholars in the similar aim of research validates this choice. Preliminary analysis shows that the research instruments adopted were dependable and reliable, therefore, they are justifiable for the methodological orientation implemented. All these aforementioned research methods have contributed to the core argument of this chapter, as it is the engine room of this study because the research instruments adopted helped to provide answers to the study objectives in order to achieve the overarching aim of the study.

3.2 THE STUDY AREA

Buffalo City Metropolitan Municipality (BCMM) is located relatively centrally in the Eastern Cape Province, which is bounded to the south-east by the long coastline along the Indian Ocean (Mahlanza, 2013). BCMM was selected for this study due to the decline of coastal vegetation resources that is witnessed in the study area. Further, BCMM has recorded the second highest population changes in the Eastern Cape from 1996 to 2011, at an alarming rate of 9.2% respectively (Provincial Gazette for Eastern Cape, 2014); and this has concomitantly led to increases in anthropogenic actions on the fragile ecosystem (Mostert, 2017). BCMM covers a total of 2,536 km^2 (979 square miles) and lies on coordinates 32°59′S and 27°52′E, and it is enclosed by the Great Kei, Amahlathi, Raymond Mlaba and Ngqushwa Local Municipalities. The area includes the large townships of Mdantsane as well as

Amalinda, East London, Bisho, Schornville, King William's Town and Dimbaza. Buffalo City is the key urban centre of the eastern part of the Eastern Cape (Benya, 2012), which consists of a corridor of urban areas, stretching from East London to the east, through to Mdantsane and reaching Dimbaza in the west (Turok, 2012). East London is the primary node, whilst King Williams Town (KWT) area is the secondary node (BCMM Report, 2017). According to Mahlanza, (2014), BCMM is broadly characterised by three main identifiable land use patterns. The first is the dominant urban axis of Dimbaza-KWT- East London – Mdantsane–KWT–Dimbaza, which dominates the industrial and service sector centres and attracts people from throughout the greater Amathole region in search of work and better access to urban service and facilities. The second is the area comprising the fringe peri-urban and rural settlement areas, which, whilst remaining under the influence of the urban axis, is distinct in character and land use patterns. These include the Newlands settlements, those settlements that previously fell within the former Ciskei Bantustan, and the Ncera settlements located west of East London. Thirdly, the commercial farming areas form a distinctive type of area (Sinuka, 2017). These areas are dominant in the north-eastern and southwestern (coastal) sectors of the Municipality and are characterised by extensive land uses, with certain areas making use of intensive farming (irrigation-based). Having a mild climate with abundant year-round sunshine, the study area records 850mm of yearly average rainfall (Zwelibanzi, 2011). BCMM has a total population of over 1,110,685, about 82% Africans, followed by 9% coloureds, 7.8% Afrikaans and 1.2% Indians/Asians, and an average population density of 300 persons per square kilometer is recorded in the study area (Statistics South Africa, 2018).

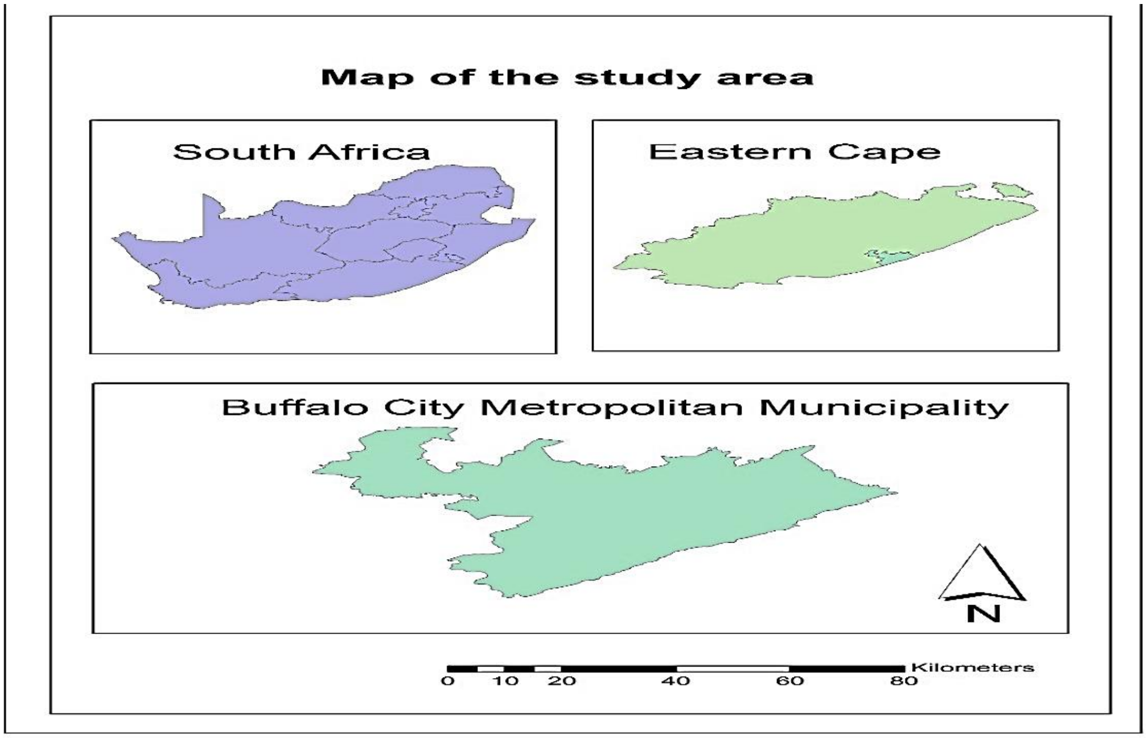
3.2.1 Geology and Topology

The study area extends from sea level along the coastal belt in a north-westerly direction to an elevation between 450 m and 850 m above MSL (Hagen, 2010). The elevation in the most north-westerly portion of the study area, the Amathole Mountains, reaches 2,100 m above MSL. The region is characterized by a number of incised river valleys, which run nearly parallel to each other in a south-easterly direction through the municipality and which break it at regular intervals (Buffalo City Municipality, 2017). The geological strata of the BCMM belong to the Beaufort Group which in turn belongs to the Karoo Supergroup, and consists mainly of mudstones and sandstones, with intruding dolerite dykes and sills (Sinuka, 2017). These dolerite dykes are generally good aquifers (Hagen, 2010). The geology and soils are derived from marine shales and result in the high concentration of salts and salinity of surface and groundwater (Sinuka, 2017). The fertile soils in most parts of the study area support the growth of coastal plant biodiversity of the study area.

3.2.2 Vegetation of the Study Area

BCMM is characterized by a diverse range of ecosystems, ranging from coastal dunes to forested hills in the hinterland and including subtropical thicket, wetlands, and riverine ecosystems (Buffalo City Municipality, 2017). According to Hagen, (2010), the major vegetation biomes represented within the BCM include subtropical thicket, afromontane forest and savanna. BCMM ecosystems are stressed and in need of conservation and remedial attention (Buffalo City Municipality, 2017). Further, they have become infested with invasive alien vegetation, while many fresh water and marine ecosystems are subjected to high levels of pollution (Buffalo City

Municipality Wetland Report, 2017). In addition, development pressure is increasingly placing coastal areas under great threat (Buffalo City Municipality, 2013). Figure 3 depicts the study area.



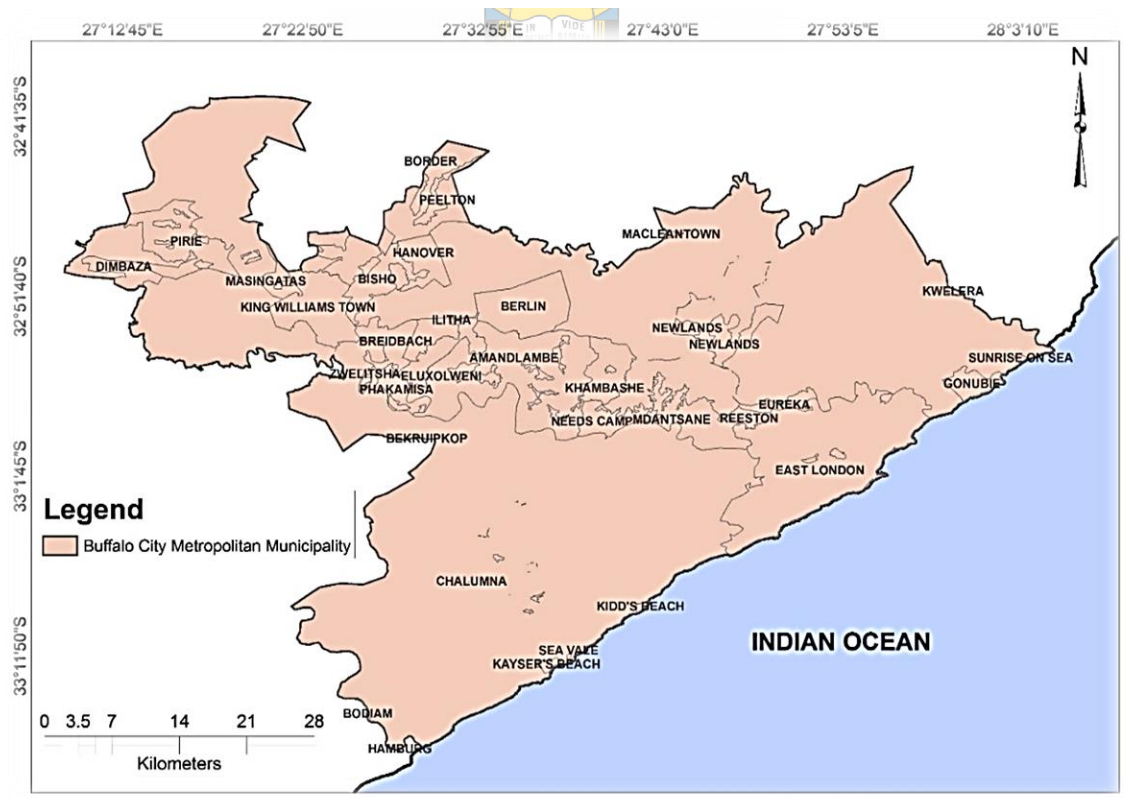


Figure 3: The Study Area

3.3 METHODOLOGICAL APPROACH

The methodology adopted for this research is the mixed method, which includes the use of more than one method of data collection in a research or set of related studies (Johnson, 2014). Mixed methods research is more specific because it includes the mixing of qualitative (chapters two and four) and quantitative data methods (Chapters five, six and seven), and/or paradigms in a research study or set of related studies (Guest, 2013; Johnson, 2014). In conformity with this, the significance of adopting a mixed methodology for studying ecosystems functioning and the impact of urban expansion on the conservation of CVEs using the interpretivist paradigm. The diagram below depicts the methodology road map adopted for this study.

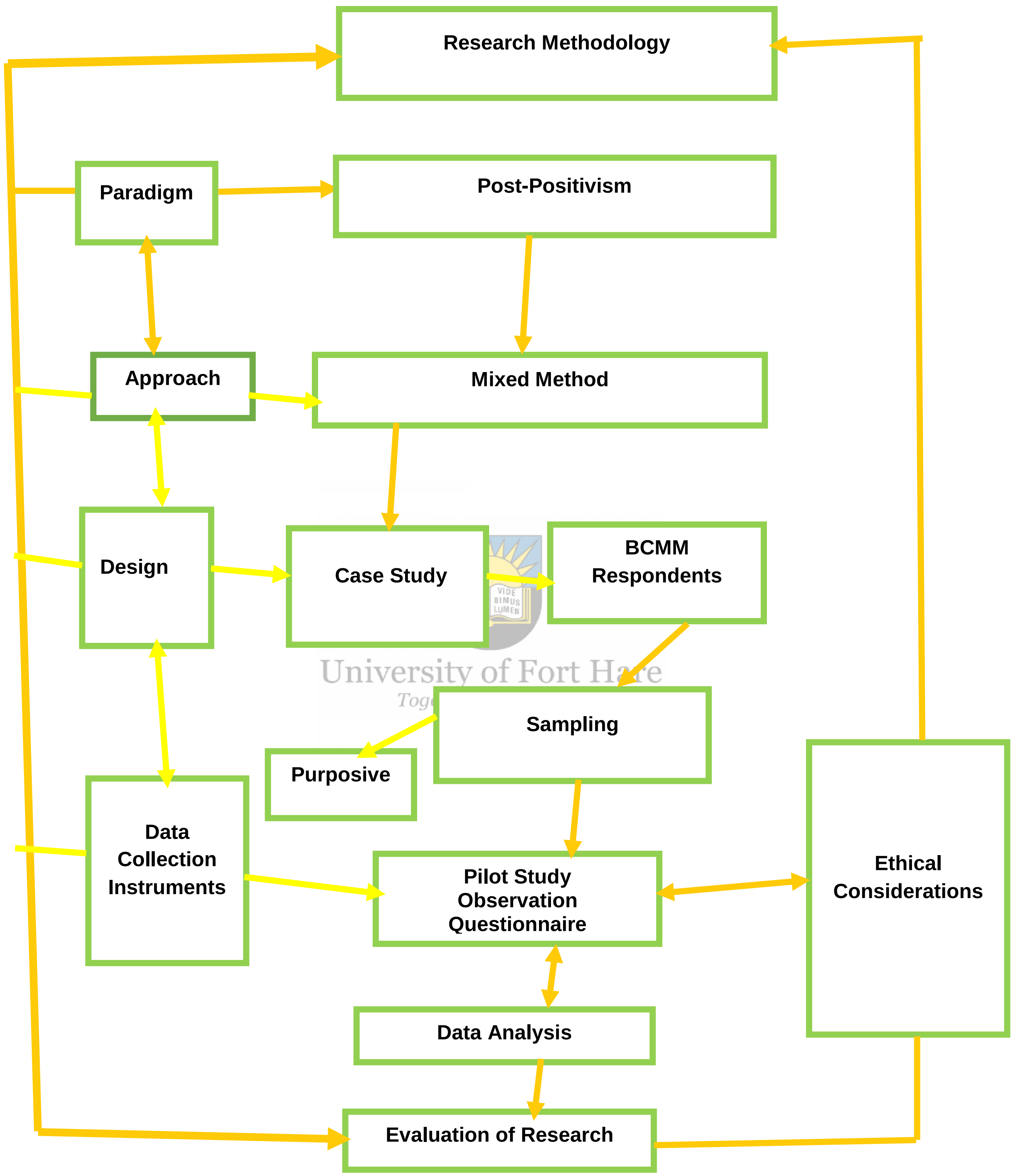


Figure 4: The Research Methodology Road Map

3.4 DATA SOURCES AND COLLECTION PROCEDURE

Letters of request for permission to access the respondents in the study area were obtained. Before the researcher visited any research site, an appointment was scheduled with the City manager of BCMM, and the researcher was provided with relevant documents pertaining to this research. Several visits were made especially for the interviews because appointments were arranged for different dates. To this end, ethical clearance and BCMM permission to conduct research were granted accordingly. Field data collection commenced from January and concluded in March 2019 using survey questionnaires, through the distribution of 300 copies of the questionnaire to different categories of BCMM respondents. Furthermore, data for this study was collected by downloading remotely-sensed satellite imageries of the study area in 1998, 2008 and 2018 respectively. This was later analysed using RS and GIS technologies to investigate change detection attributed to urban expansion on the coastal vegetation of BCMM.

3.4.1 The Survey Questionnaire

A questionnaire is a set of fixed-format self-report items that is completed by respondents at their own pace, often without supervision (Bolarinwa, 2015). The strength of using a self-administered questionnaire is that respondents exercised their right of choosing not to respond and responses are expected to be anonymous and confidential. A self-administered questionnaire, with both closed and open-ended questions, was distributed to the respondents in the study area and data were collected accordingly. A questionnaire with four sections was prepared. The narrative of what is contained in each of the sections of the questionnaire is given in the appendix. Section A of the questionnaire contained demographic/background information. The demographic and background variables include gender, age, the highest level of education and race. Section B had questions on the coastal vegetation resources. Section C of the questionnaire contained questions on challenges encountered in CVEs. Section D contained questions that targeted ecosystem goods and services, while Section E contained questions pertaining to urban expansion and conservation of CVEs. The next section discusses the methodology adopted for study objective four, which relates to the geospatial analysis of Landuse Landcover Change (LULCC) detection of coastal vegetation loss at BCMM from 1998-2018.

3.5 METHODOLOGY ADOPTED FOR THE GEOSPATIAL ANALYSIS OF LANDUSE LANDCOVER CHANGE (LULCC) DETECTION OF COASTAL VEGETATION LOSS AT BCMM FROM 1998-2018 (STUDY OBJECTIVE FOUR)

This section is focused on the methodology adopted for examining the Coastal Vegetation Landuse Landcover Change (LULLC) detection at BCMM, South Africa, and this was carried out with applications in Geographic Information Systems and remote sensing technologies, through the acquisition of satellite data on the LULC of the study area. The step-by-step methodological approach for the study objective is elucidated below.

3.5.1 Image Pre-processing of BCMM Satelite Imageries

Image pre-processing is a common name for operations with images at the lowest level of abstraction, both input and output are intensity images (Schowengerdt, 2012). The aim of pre-processing is to improve the image data to suppress unwanted distortions, and thereby enhance some image features important for further processing (Schowengerdt, 2012). Image pre-processing is carried out in land cover studies to adjust image values so as to analyze or depict information within the image and to enhance capabilities for the visual deduction of spatial phenomena characterizing an imagery. This procedure endeavours to boost the complementary capabilities of human conceptualization and computers (Clerici, 2014). In this study, predominantly multi-temporal images of 30-m Landsat 5 Thematic Mapper for years 1998, and 2008 were utilized, however, for the year 2018, Landsat 8 OLI satellite imagery was employed. A systematic archiving of remotely-sensed data gathering was obtained from the USGS website. The reason for choosing the above-named source is because is free and accessible online. The Landsat image of the study area is located along Path 169; Row 083 to Path 170 Row 083 (as identified by the Worldwide Reference System). "Path" is defined as the descending orbit of the satellite, while "Row" refers to the latitudinal centre line of a frame of imagery (Seong, 2015). The steps followed in the course of this study includes image pre-processing, feature extraction, selection of training samples, selection of suitable classification approaches, post-classification processes and accuracy assessment.

The satellite imageries were geometrically and radiometrically corrected to enhance the image quality (Guha, 2018). All Landsat 4, 5 TM and 8 OLI were auto-rectified and projected to the local coordinate system by using the WGS 84 reference system. Therefore, three landsat imageries were chosen, as guided by the merits of Jana, (2016) and Zhu, (2016). Also, all the selected images were of a good quality of less than 10% cloud cover, hence, atmospheric and radiometric corrections were carried out using ENVI 4.7 software. This is in agreement with other sources in literature, such as Deng, (2010) and Rawat, (2015), among others. The Landsat imageries were then exported to ArcGIS 10.8 software for visual inspection. Thereafter, all the bands making up the multi-temporal imageries were then combined in the GIS software. Three-band combinations (of bands 4,3 and 2) of the multi-spectral images was performed to produce the false colour images to depict forest vegetation, grassland vegetation, urban, water and bare ground features. The use of bands combinations for this study enhanced the spectral separation of the image, and this further improved the interpretability of data (Kavzoglu, 2016). The activity flow chart adopted for this chapter is presented in Figure 5.

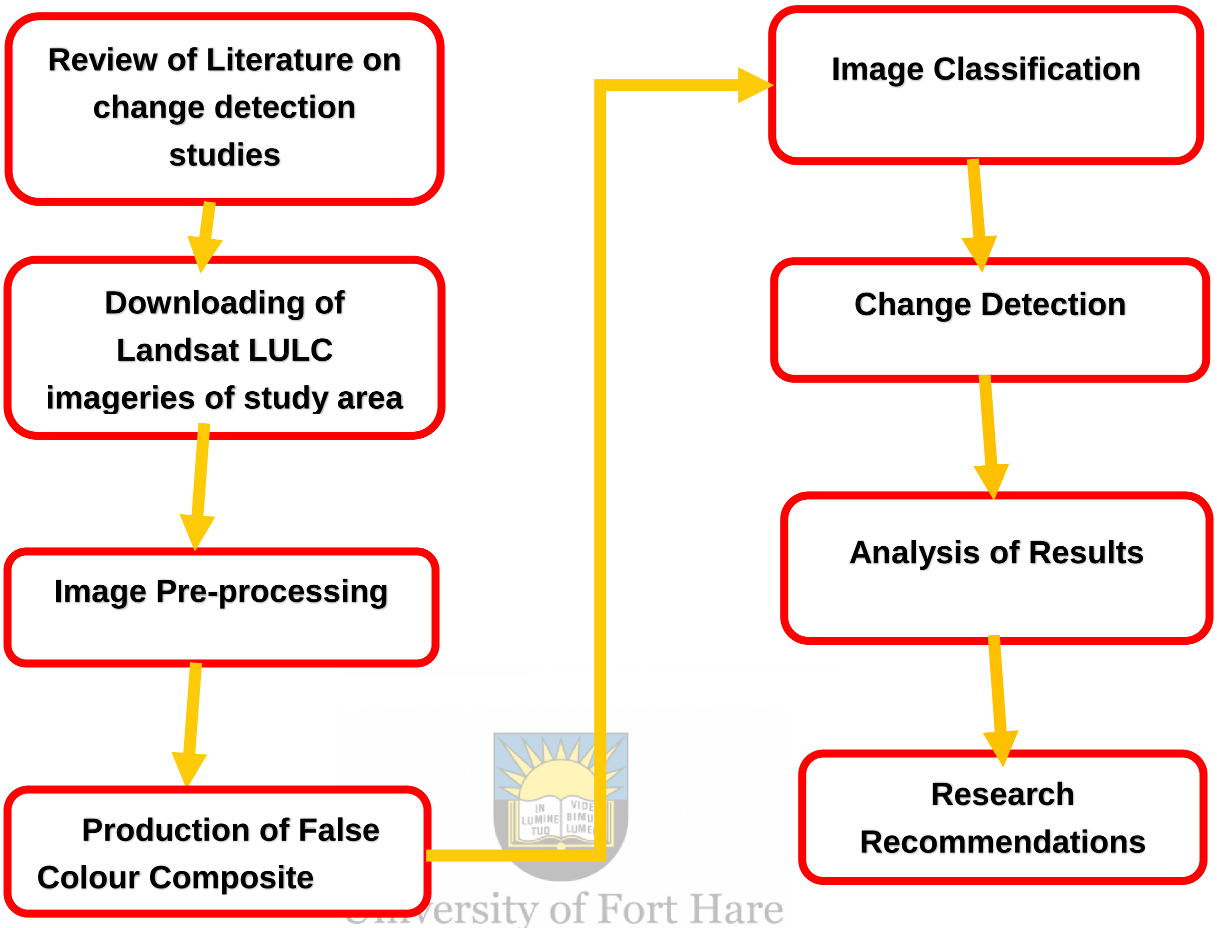


Figure 5: Activity Flow-Chart adopted for the Geo-Spatial Analysis of Landuse Landcover Change (LULCC) at the Study Area

3.5.2 Image Pre-Processing Procedure

In the course of the analysis, the researcher discovered that satellite image *169083* had better coverage than *SI -170083*. Hence, a shapefile for the area uncovered by *SI- 169083* was drawn and used to clip the needed area in *SI 170083*, northwest of the study area. Thereafter, the art of mosaicking was performed for imageries of the period under review. The art of mosaicking involves the process of combining or merging two or more images so as to create a single raster dataset from multiple raster datasets and was thereafter extracted through the feature extraction technique, (which was used to extract the features of the study area by keeping as much information as possible from a large set of data of the image. In order to enhance the interpretability of the BCMM imageries, false colour images offered insights, especially in LULC classification. They were created by assigning red, grey, and blue colours to each of the individual monochrome bands of the multispectral imageries and then superimposing them. In the urbanized setting such as the study area, FCC imageries exemplify the multispectral image generated using colour combinations that can distinguish many different functions. Vegetation appears in red colour on account of the chosen combination of bands and the reflection of near-infrared light (Steffen, 2010; Vivone, 2014; Thenkabail, 2016), and the deeper the shade of red, the more robust the vegetation, and this is due to greater reflectance of higher chlorophyll levels in the EMS (Wang, 2015). It is also essential to note that these enhanced/developed images only serve visual analyzing purposes, while the original images are utilized in the automated analysis, hence, the researcher employed contrast stretching technique on the three selected images for visual analysis, thereafter, the images were classified into five (5) classes namely: Bare ground, water bodies, forest vegetation, grassland and urban areas. The identification of these four categories was recognized on account of the visual analysis of the RS data and substantiated from ground-truthing exercises which were expedited during field work.

The demarcation of the five classes from the visually developed RS images was stress-free on account of their unique forms and characteristics. Furthermore, the selection of training samples for each of the predetermined categories of land cover types was expedited by delineating polygons around each category of land cover classes. Thereafter, the spectral signatures for the corresponding land cover categories depicted by the remotely-sensed images were derived from the pixels within the polygons. According to Al-doski, (2013) and Vivone, (2014), a spectral signature assesses success levels in LULC mapping, and hitherto minimizes misclassifications that may arise during LULC analysis. The major change detection procedure steps carried out for this study is presented in Figure 6.

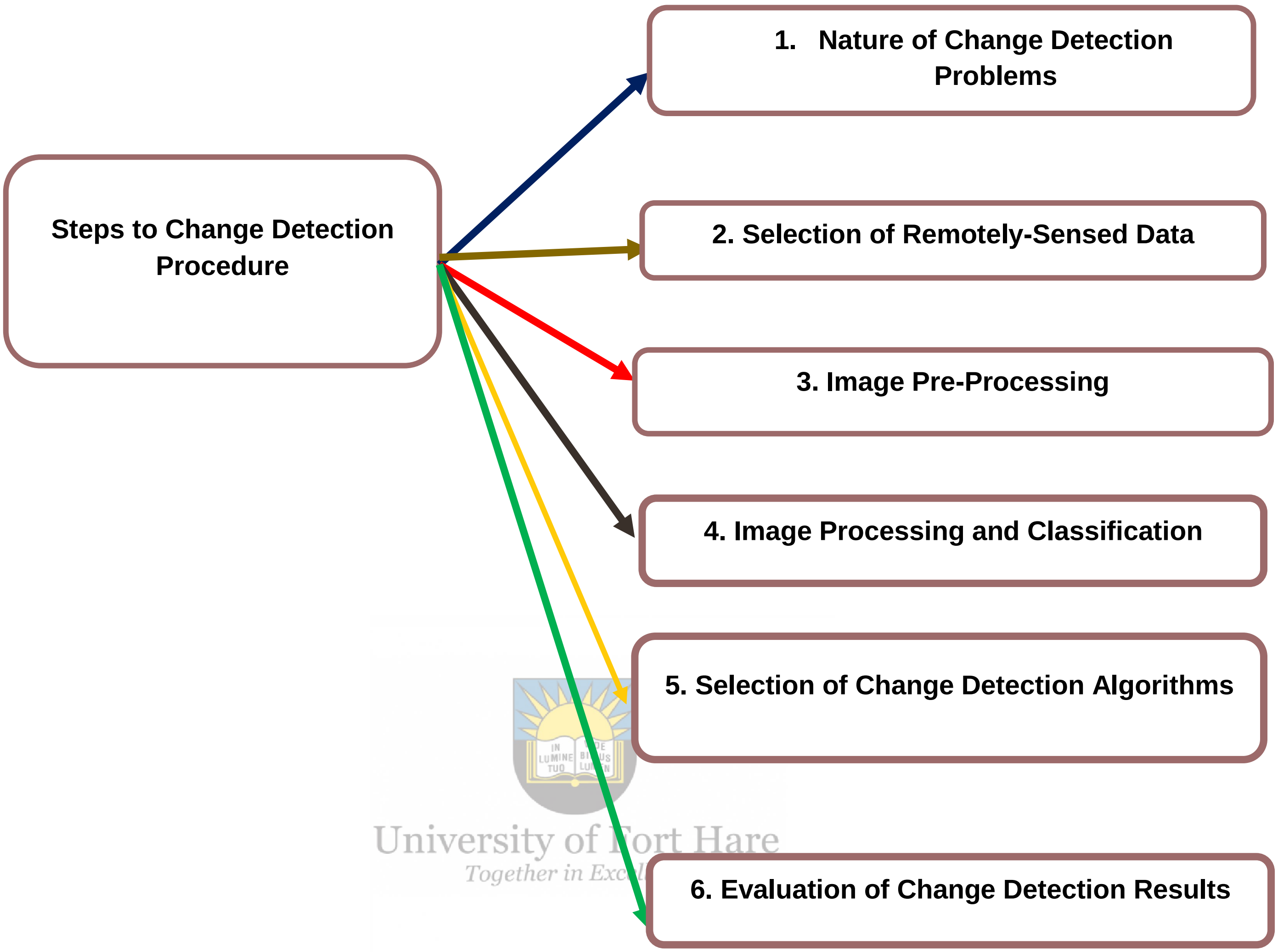


Figure 6: Major Change Detection Procedure Steps Carried out for the Geo-Spatial Analysis of the study Area (Adapted from Al-doski, 2013)

3.6 THE RESEARCH DESIGN

3.6.1 The Descriptive Research Design

The descriptive research design was employed in this study and is aligned with the Urban Green Sustainability (UGS) Theory, which promotes optimal ecosystems functioning and sustainability of coastal vegetation resources in the study area, as well as providing guidance to the analysis of the research objectives to achieve the overarching aim of the study. The descriptive research design was utilized in guiding the review of e-journals, e-databases (pertaining to ecosystems functioning, BCMM LULCC detection analysis impact of urban expansion on CVEs), magazines, e-books, reports, Landsat TM remotely sensed satellite imageries (from the United States Geological Survey website); monographs, publications (ranging from the year 2010 -2019). On the influence of urban expansion on coastal vegetation resources, challenges encountered in coastal vegetation management, as well as other anthropogenic interventions taking place in CVEs across the world in general, as well as South Africa and BCMM in specificity. Further, the descriptive research design was utilized to capture qualitative data from the stakeholders and those residing in the study area. Also, questions measuring qualitative data were structured with open-ended questions, to give respondents enough opportunity to express their views.

The descriptive research design also helped the researcher to derive first-hand information gathered through close interaction with the ecological components of BCMM. Consequently, the descriptive research design provided an in- depth understanding of the research problem, and this assertion is in coherence with Morse, (2016) and Patten, (2017). This research design type was utilized in analyzing study objectives two and three, in a bid to bring to the awareness of government and stakeholders on the uncontrolled risk of urban expansion to the ecological system in the study area, and hence the need to asses, monitor and prevent the threatened and endangered endemic coastal vegetation resources from extinction (SANBI, 2010; Pimm, 2014; Pimm, 2015).

The descriptive research design also guided the interpretation of phenomena regarding field observation techniques engaged by the researcher in the study area. This was further carried out through non-experimental method of watching, asking questions, documenting, and analyzing the observed actions, interactions and other related information pertaining to urban expansion and its impact on CVEs in the study area. The purpose of the descriptive research design enhanced the interpretation of research findings derived through the geospatial analysis of LULCC in Buffalo City Metropolitan Municipality satellite data of the study area, as well as in the process of deducing environmental challenges observed by the respondents in the course of field survey (Curtis, 2016). From the foregoing, descriptive research design played a pivotal role by providing logical, rational, intellectual and theoretical interpretation and explanations to discussions of results gathered in the course of validating the Normalized Difference Built-up Index (NDBI) and the landcover classification results from statistical analysis that combined the results of multiple scientific findings gathered in the course of this research (Siefert, 2012; Pescott, 2014; Winter, 2018). It is also germane to state that the elucidation of hypotheses results required high proficiency in data interpretation. Hence, the descriptive research design provided direction and guidance in the course of explaining the results of the twelve research hypotheses which were carried out through the binary logistic regression method (Miller, 2013). The population of the study is the next subject to be elucidated in this chapter.

3.7 POPULATION OF STUDY

After identifying the unit of analysis, the researcher identified the target population, which include government officials (provincial and municipality officials), headsmen, local leaders (area and ward councillors), Community-Based Organizations (CBOs), Non-Governmental Organizations (NGOs), graduate students, and community members residing in the study area as the unit of analysis, all totalling 254 respondents, out of which 123 (41%) respondents are national diploma and university degree certificate holders. The respondents comprised of experts in the fields of science, ecology and biodiversity conservation. Further, other respondents are officials of the Information Knowledge Management (IKM) Research and Policy Department (which is the department in charge of research in BCMM), while other respondents are long-term residents and workers in different locations of BCMM. On account of the large study population size, systematic sample techniques were adopted in determining the sample size of 300. It was determined through calculations from the Raosoft sample calculator with the level of significance at 95%, 5% error margin, 50% response distribution. Additionally, municipality officials refer to members of staff at BCMM offices at East London and King Williams' Town), while the provincial officials refer to Eastern Cape Development Corporation (ECDC) workers at various offices such as the Department of Water and sanitation, Department of Correctional Services, Statistics SA, all sited at the Ocean Terrance, Moore Street, Quigney, East London. On account of these, their perceptions are considered valid and dependable, and the survey method proved very reliable and suitable for data gathering.

3.8 ETHICAL CONSIDERATIONS

Research ethics were observed at all stages of this research. This study adheres with the University of Fort Hare (UFH) research ethics and BCMM coastal vegetation conservation policies. The author received approval from UFH authorities, and the ethical clearance certificate number for this study is *KUL011SOLA01* (refer to Appendix one). In addition, respondents' anonymity, privacy and data confidentiality were strictly adhered to during the researcher's interaction with respondents. Also, the respondents were duly informed about the aim of this study and were guaranteed of their privacy and anonymity rights, and this also takes account of their consent rights, protection of respondents' respect to the privacy and individual perception in the course of data gathering and reportage. Below is an explanation of the structure of this research.

3.9 ADOPTED STRATEGIES FOR ANALYZING DATA

The required data for this study was structured, branded and evaluated through quantitative and qualitative means, as these two procedures, (that is quantitative and qualitative) both provided high levels of complementarity and reliability in the course of generating the wide array of required information for this study. They also allowed for the comparison of data. It is also worthy of note to state that the demerits of one technique was overshadowed by the merits of the other and vice-versa.

3.9.1 Quantitative Data Analysis

In the present study, the quantitative approaches were employed in the course of investigating objectives two, three and four, on issues pertaining to ecosystems functioning, conservation of ecological goods and services, the impact of urban expansion on the conservation of CVEs, as well as in the geo-spatial analysis of LULCC detection in the study area. The quantitative research approach was applied because it allowed for quantification of the variables on ecosystems functioning as well as the impact of urban expansion on the conservation of coastal vegetation. It is imperative to collect quantitative data in order to compare and contrast questionnaire results from the survey questionnaire and reviewed documents, so as to enrich the data and thereby assisting the researcher to complete and substantiate the research results ecosystems functioning and the impact of urban expansion on the conservation of CVEs. The data obtained for this thesis was derived through self-administered survey questionnaires, with the determination of generalizing perceptions from the study population, which are the BCMM respondents. The quantitative techniques adopted for this study was carried out to analyze study objectives two, three and four. The research instrument involves a total of 300 copies of the questionnaire, which were administered to BCMM respondents, out of which 254 copies were returned. According to Cohen, Manion and Morrison, (2011), a major feature of quantitative data analysis is coding. Coding was used in the analysis of quantitative data of this study so as to reduce the time required to analyze data and reduce errors involved in coding and analyzing data. In the present study, a code was assigned to each category or variable that contained an idea or a piece of information that relates to each item from the questionnaire. The results of the data analyzed were presented in the form of tables, figures, charts and verbal descriptions. Data obtained from the study were analyzed using the Statistical Package for the Social Sciences (SPSS). SPSS enabled the researcher to input, organize, modify, label and analyze data to carry out a wide range of simple, statistical analyses. From the foregoing, SPSS was used in analyzing the twelve research hypotheses for this study, which was achieved by determining odd ratio through logistic regression technique (as supported in the literature by Sperandei, 2014; Speelman, 2014). Logistic Regression (LR) is the appropriate regression analysis to conduct when the dependent variable is dichotomous (binary) (Morgan, 2014). According to Speelman, (2014), LR is a statistical method for predicting binary classes, which was applied to measure the relationship between binary variables on knowledge of conservation and ecosystems functioning, goods and services provision. Logistic regression is used to describe data and to explain the relationship between one dependent binary variable and one or more nominal, ordinal, interval or ratio-level independent variables (Mfotabong-Atheull, 2013). LR is used to obtain the odds ratio in the presence of more than one explanatory variable. The procedure is quite similar to multiple linear regression, with the exception that the response variable is binomial (Heale, 2015). The result is the impact of each variable on the odds ratio of the observed event of interest. LR analysis is most often used in this study as a predictive modelling algorithm on issues pertaining to knowledge application on one hand and ecosystem functioning/services provision and influence of urban expansion on CVEs on the other (as analyzed in Chapters Five and six respectively). Further, the odds ratio in LR analysis represents the constant effect of a predictor X (which is knowledge of ecosystems conservation), by measuring its unique effect on the Y variable (ecosystems functioning and influence of urban expansion on CVEs). Hence, a good odds ratio should be less than 1. Further, Speelman, (2014) states that the p-value of LR analysis tests the null hypothesis that the coefficient is equal to zero (no effect).

A low p-value (< 0.05) indicates that you can reject the null hypothesis. Typically, the coefficient p-values determine which terms to keep in the regression model. Hence, the smaller the p-value, the stronger the evidence that you should reject the null hypothesis. A p-value less than 0.05 (typically ≤ 0.05) is statistically significant. It indicates strong evidence against the null hypothesis, as there is less than a 5% probability the null is correct (and the results are random).

Additionally, Pearson's Product Moment Correlation Matrix (PPMC) technique was employed in determining accuracy levels of results derived from the assessment of correlation between BCMM landcover types and Normalized Difference Built-Up Index (NDBI) Classification results. Further, the coefficient of determination (R^2) an Kappa coefficient technique was carried out to test the level of performance, correlation and reliability of the landcover types to the NDBI results, and this was analysed in a Microsoft Excel environment. Additionally, the spatio-temporal change detection analysis of BCMM (for 1998, 2008 and 2018) was analyzed using ArcGIS 10.8 software. All these aforementioned research methods have immeasurably contributed to the overall success of this study by providing answers to the study objectives.

3.9.2 Qualitative Data Analysis

Qualitative data were analyzed using thematic analysis. From the foregoing, the qualitative data collection approach was expedited in the review of literature on ecosystems functioning, the legal frameworks on biodiversity conservation in BCMM; as well as the impact of urban expansion on the conservation of CVEs in the study area. Additionally, the research instrument involves close observations of issues related to this study, as well as indepth review of related documents. The presentation of qualitative data involved the discussions of themes and major concepts of this study. The researcher also considered the expediency of mapping the study objectives to sources of data used in this research, in Table 2.

TABLE 2: MAPPING OF STUDY OBJECTIVES TO SOURCES OF RESEARCH DATA

S/N	Study Objectives	Purpose of Study Objective	Sourcing of Data & Procedure Adopted for Analysing Data
1.	To critically assess the performance and implementation of the Integrated Development Plan and the spatial development framework regarding the conservation of the coastal vegetation of Buffalo City Metropolitan Municipality (BCMM)	The purpose of this objective is to critically evaluate the implementation of IDP and SDF conservation efforts of CVEs at BCMM due to the occurrence of environmental degradation and coastal vegetation loss at BCMM.	Thematic evaluation; Field observation; Review of literature on the SDF and IDP development plans; Assessment of the performance and implementation of the development plans.
2.	To examine the ecosystem function, and the conservation of ecological goods, services and economic benefits derivable from coastal ecological systems by BCMM residents. (Chapter Five).	The purpose of this objective is to have a well-documented inventory of the available ecosystem goods and services at BCMM.	Thematic evaluation; Review of the literature; Fieldwork; Quantitative data analysis of questionnaire results on the obtainable ecological goods and services.
3.	To determine the impact of urban expansion on the conservation of coastal vegetation Environments in BCMM (Chapter Six).	The purpose of this objective is to investigate the impact of urban expansion on coastal vegetation loss at BCMM.	Thematic evaluation; Review of the literature; Fieldwork; Quantitative data analysis of the impact of urban expansion on CVEs in the study area through analysis of questionnaire.

4	To investigate the coastal vegetation LULCC detection of BCMM from 1998 to 2018 using geo-spatial technologies. (Chapter Seven)	The purpose of this study objective is to further verify questionnaire results regarding coastal vegetation loss attributed to urban expansion at BCMM.	Thematic evaluation, review of literature, field observation, quantitative data analysis of study area using RS and GIS techniques to perform LULCC detection of study area from 1998-2018

3.10 RELIABILITY AND VALIDITY

Reliability is the degree to which the indicator or test is a consistent measure over time (DeVellis, 2016). Reliability is about dependability and consistency, and this was measured using the pilot test method, through the distribution of copies of the questionnaire to Raymond Mhlaba Municipality officials (Alice), and lecturers in the Botany and Agronomy Departments, University of Fort Hare, Alice Campus based on their research experience on vegetation conservation. (Heale, 2015; Bolarinwa, 2015). The reliability analysis of the questionnaire variables was measured using the Cronbach's alpha (CA) technique in SPSS, which measured the consistency of the ecosystems functioning and the impact of urban expansion on CVEs. The results indicated a high value of 0.849, hence the variables were proved valid and reliable. The author also validated the LULC classification results by performing the Normalized Difference Built-Up Index (NDBI) by carrying out the coefficient of determination (R^2), Kappa coefficient (k) and Pearson's Product Moment Correlation (*P*) tests, and all tests revealed very good and highly correlated overall classification accuracies (of R^2=0.89 and P=0.86) during the study period.

3.10.1 Field Observation

The qualitative aspect of the research was facilitated by field observations carried out in the CVEs of the study area. From the foregoing, the researcher visited the study area on many occasions for the purpose of making scientific observations relating to the impact of urban expansion on the conservation of coastal vegetation. The essence of observation in research as a field technique is to ensure reliability, validity and veracity of information acquired (Pickard, 2011). In carrying out this duty, the researcher designed an observation checklist which include types of ecological goods and services, benefits derivable from the study area as well as the impacts of urban expansion on the CVEs of the study area.

TABLE 3: LOCATIONAL DISTRIBUTION OF QUESTIONNAIRE TO RESPONDENTS AT BUFFALO CITY METROPOLITAN MUNICIPALITY

Category of Respondents	Sample Size and % of Respondents	Data Collection Areas
Municipality Officials	60 (20%)	BCMM Head Offfice, Oxford Street, Dimbaza, Office of the Premier (Bhisho), KWT
Provincial Workers	32 (11%)	Eastern Cape Development Corporation Statistics SA, Dept of Water ad Sanitation (Quigney), Oxford Street, Moore Street, Phakamisa
NGOs	20 (7%)	Afesis- Corplan (Southernwood), South African Red Cross Society, Rural Support services (Southernwood), Rural Support Services, Imithayelanga Youth Development, Nahoon River Picnic Park
CBOs	28 (9.3%)	Mpongo Private Game Reserve Umtiza (Macleantown District), East London Coast Nature Reserve, James Pearce Park
Ecologists	14 (5%)	Information Knowledge &Management Office, Dept. of Education (Bhisho), Zwelitsha, Gonubie, East London Zoo officials, Nahoon, Oxford Street, Bisho, Quigney, Clubview, Tshabo 2
Local Leaders	10 (3 %)	Duncan Village, Phakamisa, Nomgwadla
Graduate students	02 (1%)	University of Fort Hare (UFH), East London
Community Members	134 (44%)	UFH Administrative/academic staff, Amathole Museum (KWT), Dept. of Higher Education & Training (KWT), Bhisho Post Office, Office of the Premier (Bhisho), UFH undergraduate students Nahoon, Dept of Public Works (Bhisho)
TOTAL	**300**	

3.11 PARTICIPATION RATE

According to Stangor, (2011) participation rate refers to the percentage of respondents who actually completed the questionnaire and returned the same to the investigator. Of the 300 copies of the questionnaire administered in this study, 261 were returned, 7 were unusable because they had been damaged by the respondents, meaning that only 254 were used in the study for the analysis, thereby providing an overall participation rate of 84.7%. To guard against possible lower and non-response that would weaken the survey, the researcher collected data from the respondents in their various locations. The retirees and unemployed respondents were not restricted as regards the timing of the field survey. The participation rate by category is presented in Figure 7.

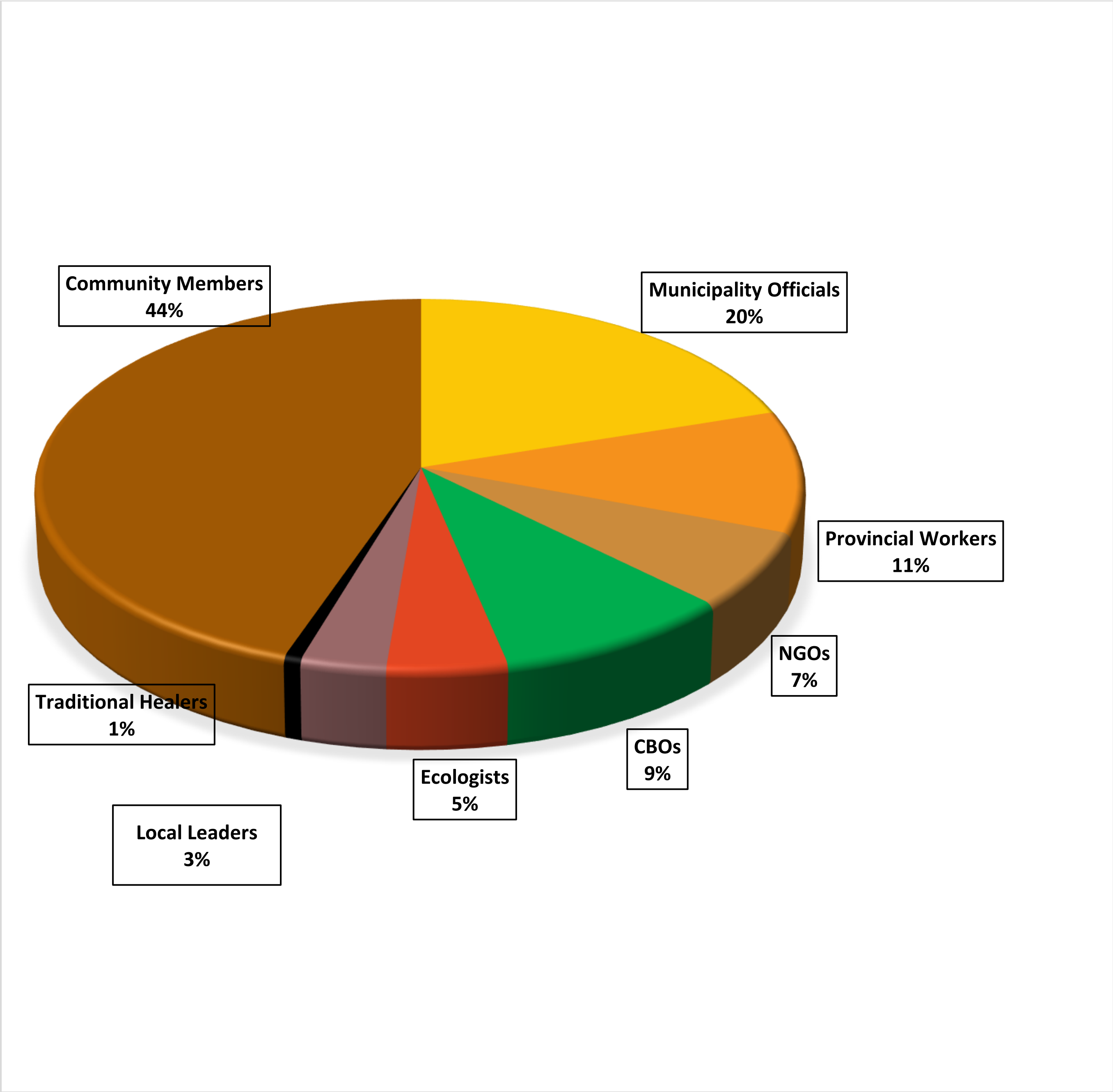


Figure 7: Participation Rate by Category of Respondents

Figure 7 reveals that the highest category of respondents were the community members numbering 134 respondents (44%), comprising of workers in corporate organizations such as retail shops and multinational companies in different parts of BCMM) the second highest category of respondents were the municipality officials, numbering 60 respondents (20 %), and this group comprises of those respondents working at the Eastern Cape Development Corporation (ECDC), in various offices such as the Department of Water and sanitation, Department of Correctional Services, Statistics SA, all sited at the Ocean Terrance, Moore Street, Quigney, East London. Other respondents include CBOs, constituting 9%, while others reside in parts of Zwelitsha, King Williams Town, Bisho, East London, Dimbaza, just to mention a few. The overall participation rate for this study is 84.7 %.

3.12 DATA RESPONDENTS DEMOGRAPHIC CHARACTERISATION

Demographic characterization refers to the statistical socio-economic characteristics or variables of a population these include age, gender, educational level, income level, marital status, occupation, religion, birth rate, death rate, the average size of a family, the average age at marriage. In this study, a total of 254 key respondents participated, which were drawn from BCMM. The respondents comprised of experts in the fields of science, ecology and biodiversity conservation. Further, other respondents are officials of the Information Knowledge Management (IKM) Research and Policy Department (which is the department in charge of research in BCMM), while other respondents are long-term residents and workers in different locations of BCMM (as specified in the methodology chapter). Other respondents include provincial workers attached to the Eastern Cape Development Corporation

[ECDC], who work in various offices such as the Department of Water and sanitation, Department of Correctional Services, Statistics SA, at the Ocean Terrance, Moore Street, Quigney, East London. On account of these, their perceptions are considered valid and dependable, and the survey method proved very reliable and suitable for data gathering. Also, respondents with the national diploma and degree certificates constituted 123 respondents, as well as staff members attached to the City Manager's office. This offered rich information about the impacts of urban expansion on ecosystem functioning in the study area.

3.13 Study Key Respondents Demographic Characterisation

The demographic characteristics of the respondents were analyzed from data gathered from Section A of the questionnaire pertaining to age, gender, race, and academic qualification of respondents, and are analysed in subsequent sections.

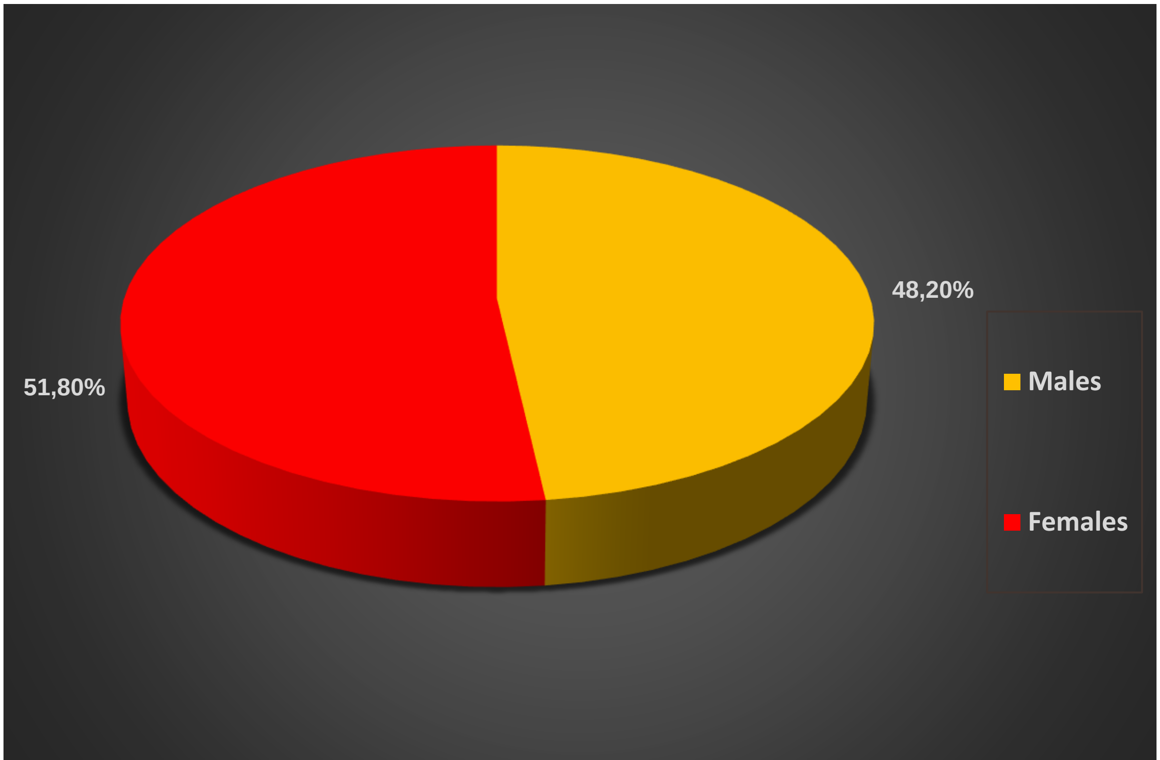


Figure 8: Gender of respondents

Figure 8 provides a description of the gender of the respondents, and it reveals that 121 respondents were males, while the residual number of 133 were females. It was also observed that both males and females are actively involved in conservation efforts in the study area. The next section discusses the age distribution of BCMM respondents.

3.14 Age Distribution of Respondents

Age is conceptualized as the longevity of a person or phenomenon that ever lived or existed. WHO, (2011) states that age is the longevity or amount of protracted time of one's existence and life duration. According to Statistics South Africa, (2019), the age distribution is as follows: 20-25 years (early working age), 25-54 years (prime working age), 55-64 years (mature working age), 65 years and over (elderly). The age structure of the South African population affects the country's key socio-economic development issues. The age of respondents is important to this study because most of the respondents are knowledgeable on the ecological conservation. The age of the respondents fall into different groupings as depicted in Figure 9.

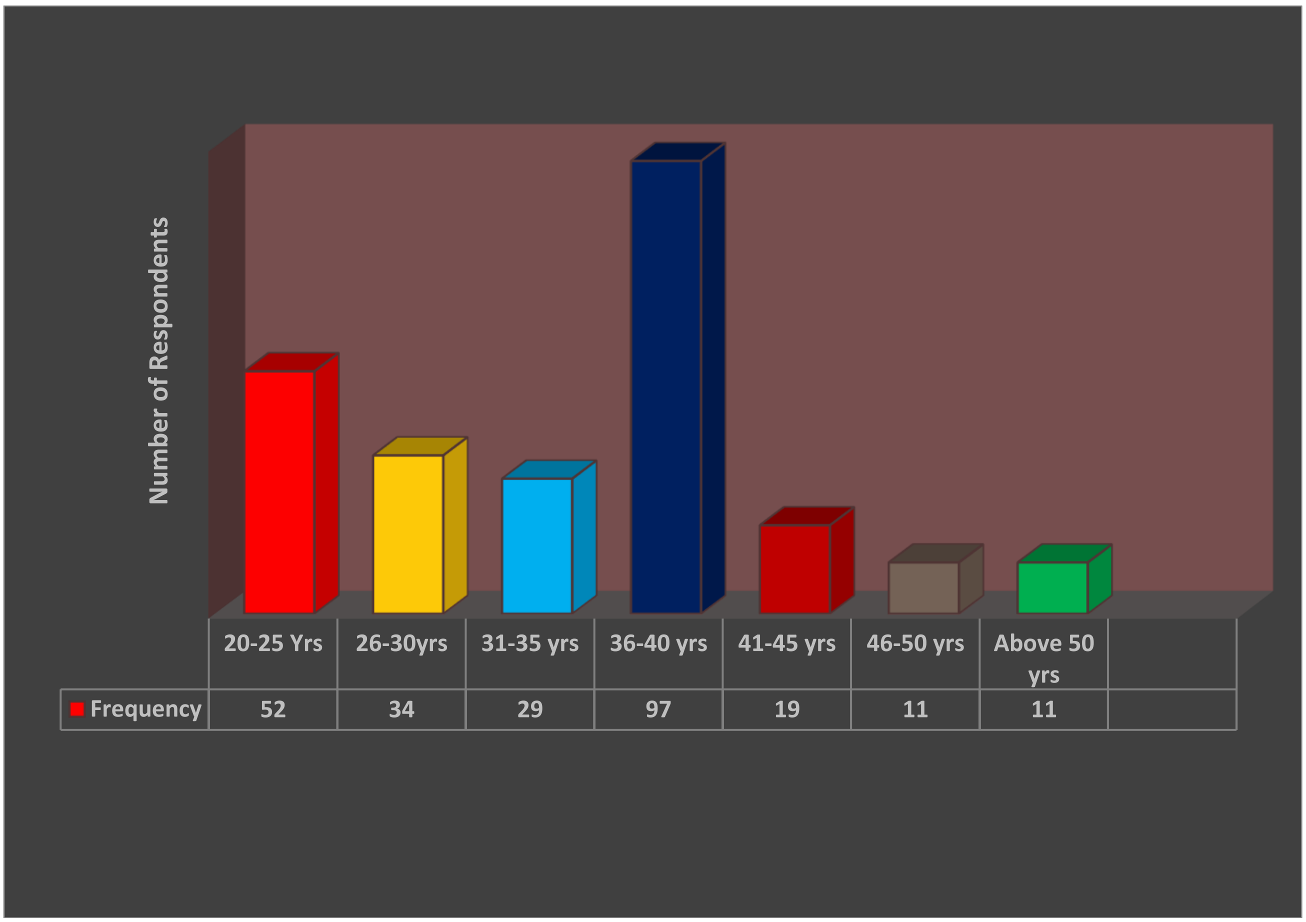


Figure 9: Age distribution of the respondents

Figure 9 depicts the age distribution of the respondents. From the foregoing, the respondents that were between 36- 40 years old were in the majority.

3.15 Educational Attainment of Respondents

Educational qualifications refer to diplomas, certificates and degrees that an individual has accomplished. In 2018, over half (59%) of 25-64 year-olds in South Africa had attained an upper secondary education as the highest level achieved, well above the G20 average of 32% and the OECD average of 38%, while 26% had not attained upper secondary education. According to StatsSA (2018), the province with the highest adult literacy rate is the Eastern Cape (20.5%), and this is the province where BCMM is located. This is closely followed by Limpopo (19.7%) and Northern Cape (19.1%). Figure 10 displays the results from the third question in the survey form, which refers to the level of educational attainment of the respondents, and reveals that 123 of the respondents (41%) possessed university degrees (such as honors, masters and Doctor of Philosophy degrees from various higher education institutions), while 104 respondents were matriculated. Figure 8 presents the respondents' educational status.

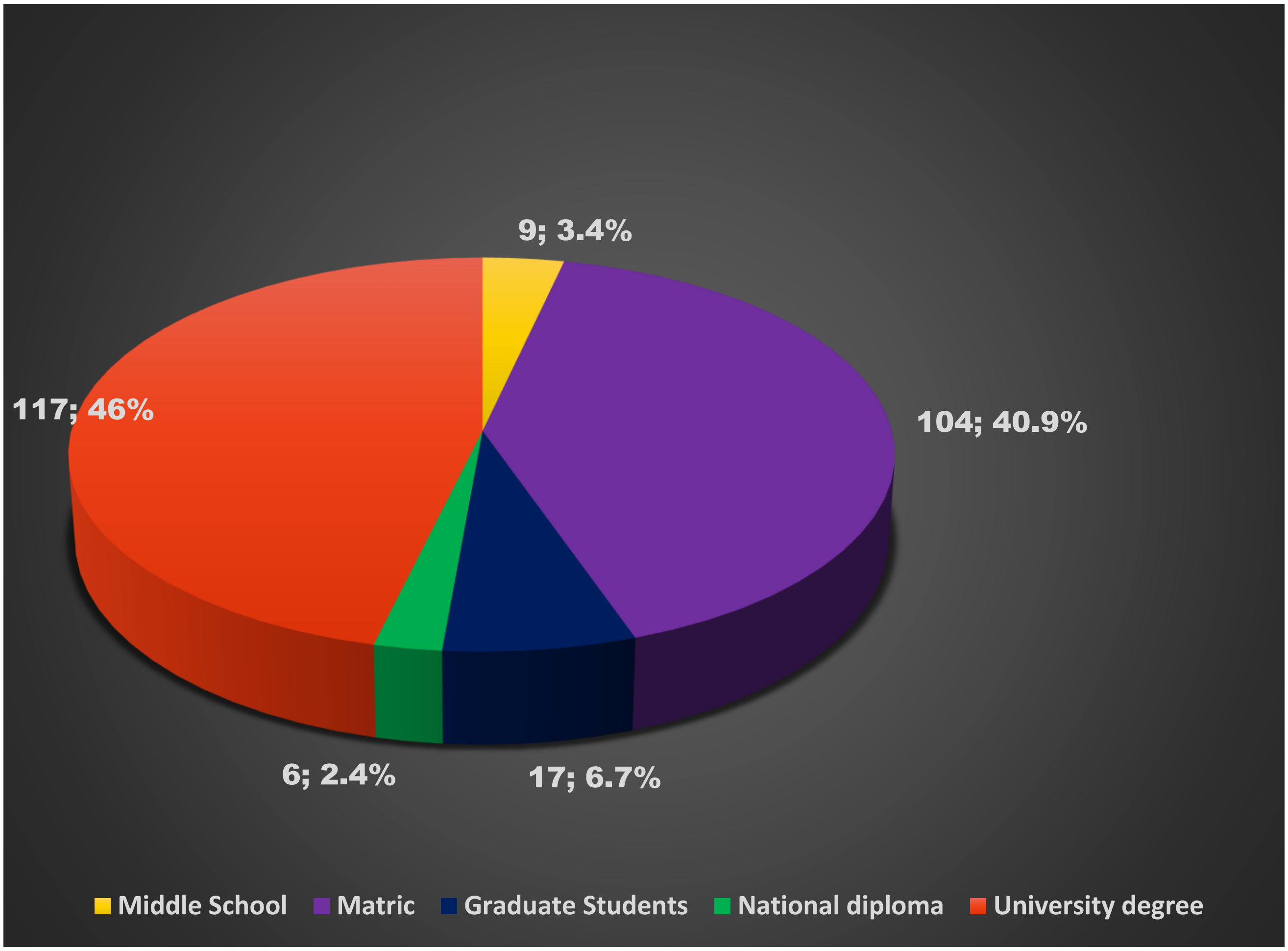


Figure 10: Educational attainment of the respondents

3.16 Race of Respondents

The race of the respondents was also analysed in the course of the field survey. The respondents were classified into one of four groups: 'Blacks', 'coloured', 'Asian' ‘indian ’or 'white', and this was classified according to South African standards. For this study, 172 respondents (about 68.0%) were predominantly blacks (who were either Xhosas, Zulus or other foreign nationals), while respondents that are coloured (those who are majorly Afrikaans) were 33 (13.04%). Also, the white population of surveyed respondents were 16, were mostly East London dwellers, while 7 respondents (about 2.8%) were Asian. The race of respondents is presented in Figure 11.

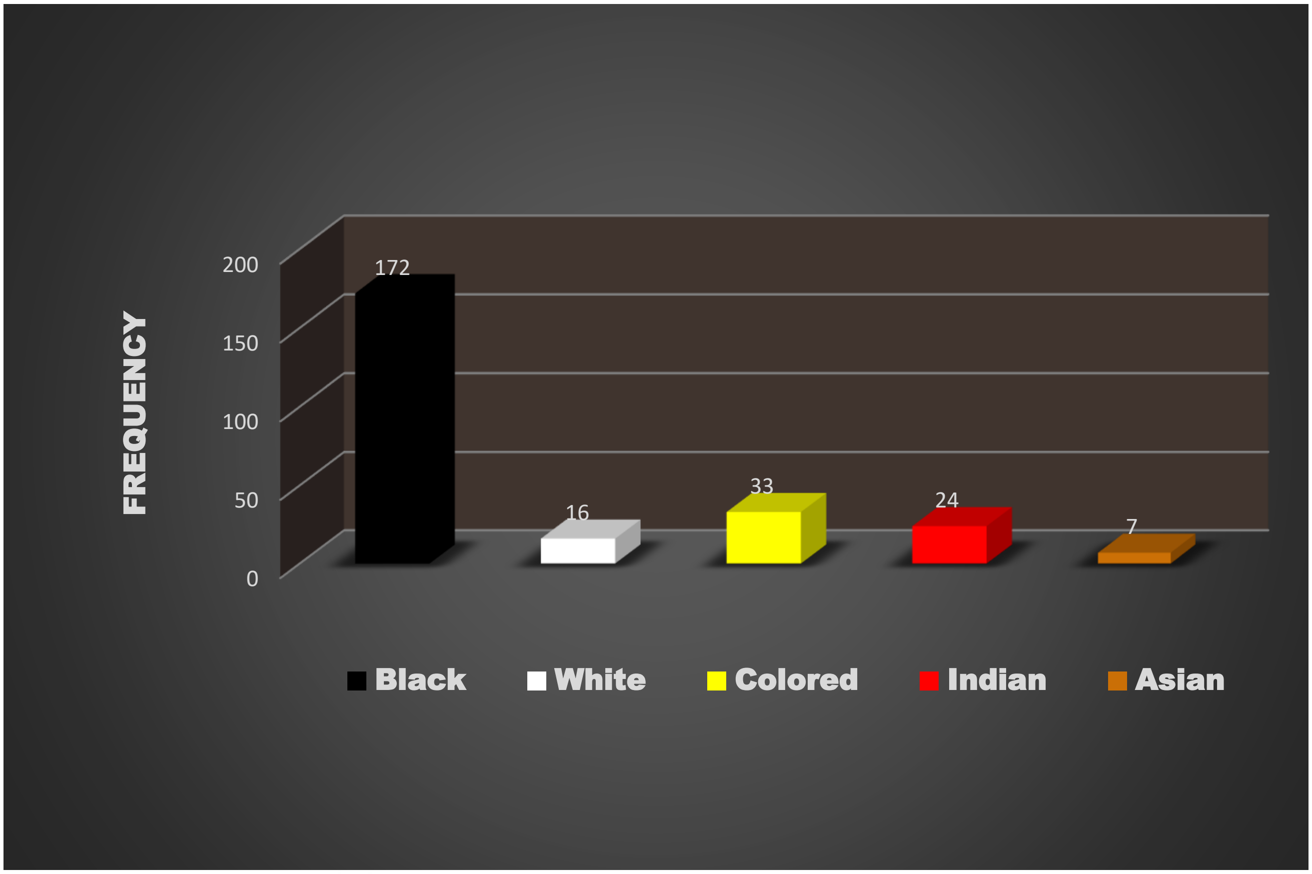


Figure 11: Race of respondents

3.17 CONCLUSION

Chapter Three outlined the research methodology of the study. The required data for this study was structured, branded and evaluated through quantitative and qualitative means, as these two procedures, (that is quantitative and qualitative) both provided high levels of complementarity and reliability in the course of generating the wide array of required information for this study. They also allowed for the comparison of data. Hence, this study aptly and sufficiently demonstrates mastery of utilized methodological approaches. This chapter dealt with the research methods, research design, participation rate, study population, and the procedure for gathering data, techniques for analyzing data, as well as the approaches expedited in the course of ascertaining validity and reliability of research instruments, which all combined to bring about the desired research results, and this made it possible to formulate a rich core argument which aligns with the total findings of the study that urban expansion has negatively impacted the conservation of coastal vegetation resources in the study area.

CHAPTER FOUR

A CRITICAL ASSESSMENT OF THE PERFORMANCE AND IMPLEMENTATION OF THE INTEGRATED DEVELOPMENT PLAN AND SPATIAL DEVELOPMENT FRAMEWORK REGARDING THE CONSERVATION OF THE COASTAL VEGETATION OF BUFFALO CITY METROPOLITAN MUNICIPALITY (BCMM)

4.1 Introduction

The main purpose of this chapter is to critically evaluate the performance and implementation of the policy documents (SDF and IDP), as it relates to urban expansion and conservation of Coastal Vegetation Environments (CVEs) in the study area. The performance of the spatial development policies is dependent on the local authorities to ensure the implementation of the IDP and SDF legislation and development policies. From the foregoing, the municipality is empowered by law to annually review and budget for the spatial development and coastal management of the study area. The roles and functions of BCMM have evolved since the South African post-apartheid era, because of the fragmented space (which typifies the spatial configuration of the municipality in the colonial era (Midvaal, 2018).

4.1.1 The BCMM Spatial Development Framework (SDF)

The South African Municipal Systems Act No. 32 of 2000 provides for the adoption of the SDF, which is a spatial integration component of the IDP, and serves as a germane urban spatial instrument for the development of the study area (Turok, 2012). Additionally, attributes, sensitivities and developmental objectives of the BCMM urban space are also entrenched in SDF document of the study area.

According to Nel, (2019), BCMM SDF assists in channeling of desired spatial expenditures and investment within the study area. SDFs serve as valuable guide in spatial development of the study area, as well as providing required information for decision-making on urban land-use operations.

4.1.2 The BCMM Integrated Development Plan (IDP)

According to the BCMM Report, (2017), the BCMM IDP is an established management tool and a strategic planning instrument, which conveys the metro's IDP. In addition, it is an all-inclusive document encompassing all facets of BCMM plans through coordinated planning and development (Sinuka, 2017). Further, the metro's IDP is periodically reviewed every five years regarding the spatial development priorities and needs together with investment channeling and budgeting (Sinuka, 2017). The metro's IDP ensures guidance on spatial development and tools for land-use control purposes. Associated with the aforementioned is the inclusion of all aspects of environmental sustainability interests within the IDP document (Nel, 2019). The influences of the IDP document to urban spatial planning and development of the metro depends on the following considerations, namely: a) the BCMM long-term developmental goals, b) current developmental levels, (c) development priorities, strategies and objectives, as well as (d) the Spatial Development Framework (SDF) of the metro. (Cilliers, 2014). This provides for valued and channeled direction towards the design and development of the metro's urban development projects (Schoeman, 2015). Consequently, the metro's IDP document is a working instrument providing planning directives and incorporates environmental interest within the metro's urban space in a bid to drive progressive and responsible spatial and environmental development (Berrisford, 2011).

The Spatial Development Framework (SDF) and Integrated Development Plan (IDP) are formulated for the main purpose of redressing the imbalances generated by the apartheid regime. The IDP and SDF are documents that address future developmental opportunities and challenges of municipalities and are channelled by a realistic goals that are contextualized in order to actualize the vision and statements of the municipality. According to Cilliers, (2014), the primary objectives of these documents include the following:

- They uphold the general well-being of all BCMM dwellers, thereby guaranteeing the attainment of an efficient systematic, and well-ordered municipality to the overall advantage of its inhabitants.
- They foster developmental strides in the spatial organization of the municipality through the enactment of spatially sustainable development goals and supporting programmes.
- They endorse sound planning objectives according to the relevant policies.

4.2 THE EVOLUTION OF SPATIAL PLANNING AT BCMM SINCE 1994 POST-APARTHEID ERA

Spatial planning in BCMM has evolved since the 1994 South African post-apartheid period. The purpose of studying spatial planning in the post-apartheid era is to assess changes in spatial development in the study area after the abolishment of the apartheid regime. The consequences of the post-apartheid policies on spatial development of south African urban space, and the study area inclusive is characterized by disintegration and uneven accessibility to public amenities, occupations as well as social facilities. This abysmal inheritance has not been totally eradicated in the aftermath of apartheid due to the structure of urban areas, interests of certain individuals with ulterior motives, lack of upward mobility as well as incessant disparities of wages and income along racial lines. The fragmented urban spaces of East London, for instance, demands longer travels from other parts of the study area (such as King Williams Town, Bisho, Dimbaza, and so on), increases the release of carbon, diminishes production levels in the CBD, and weakens the economic potentials of the metro area as a whole on account of increased costs of maintenance. During the period under review such as Sleeper site, Quenera, Dimbaza, Amalinda, Westbank, parts of Bisho and Berlin, just to mention a few. Some areas were largely environmentally degraded, mostly rural, unplanned and lacked basic amenities (BCMM Report, 2017). From the foregoing, the spatial development of the aforementioned areas is in progress, as urban renewal initiatives, which has been prioritized into three categories is been expedited around East London CBD, Quigney, sleepers site, west Bank, Bisho Berlin and parts of King Williams Town. In addition, there is an uneven distribution of population in favour of areas such as East London, when compared to areas such as Duncan village, Amalinda, Abbotsford, Nahoon Valley, and so on. This colossal unevenness is resultant from the spatial fragmentation of BCMM space, which has concomitantly resulted in spatial management problems as well as social disintegration problems in the urban areas of the metro, especially as buffers often partition different vicinities in the study area. Consequently, the spatial development plans are viable documents regarding the development of the study area vis-à-vis the conservation of coastal vegetation resources in this regard.

4.3 THE PURPOSE OF THE IDP AND SDF IN THE COASTAL CONSERVATION OF BCMM

The IDP and SDF documents for BCMM have been compiled to support the coastal conservation of Buffalo City Metropolitan Municipality's (BCMM). Also, the population of inhabitants in the study area is ever-increasing, and as a result, provision has to be made to develop the spatial environment to cater for the teeming population (Turok, 2012). Further, Stats SA 2011 census figures revealed that the population for BCMM is over 766,000 (and about 257,000 households with an average household size of 3.2 persons). Also, an estimated growth of 54, 000 people over a 10-year period (from 2015 to 2025) was projected, hence, it is imperative to take into cognizance the spatial requirements for the conservation of the CVEs in the study area. Further, three spatial areas of priority were proposed in the SDF document, and if the proposed coastal conservation plan is implemented, it will result in enormous sustainable conservation of CVEs vis-a-vis spatial development of the study area. The first three areas of priority include the West Bank (which is prospective for massive urbanization in the Greater East London area); Bisho and King William's Town. Bhisho serves as the administrative capital of the Eastern Cape Province, while King Williams Town serves as the threshold for extended rural service in BCMM). Figure 12 depicts the BCMM SDF coastal conservation plans.

Fi*gure 12: BCMM Coastal Conservation Plans (adapted from: BCMM 2017*

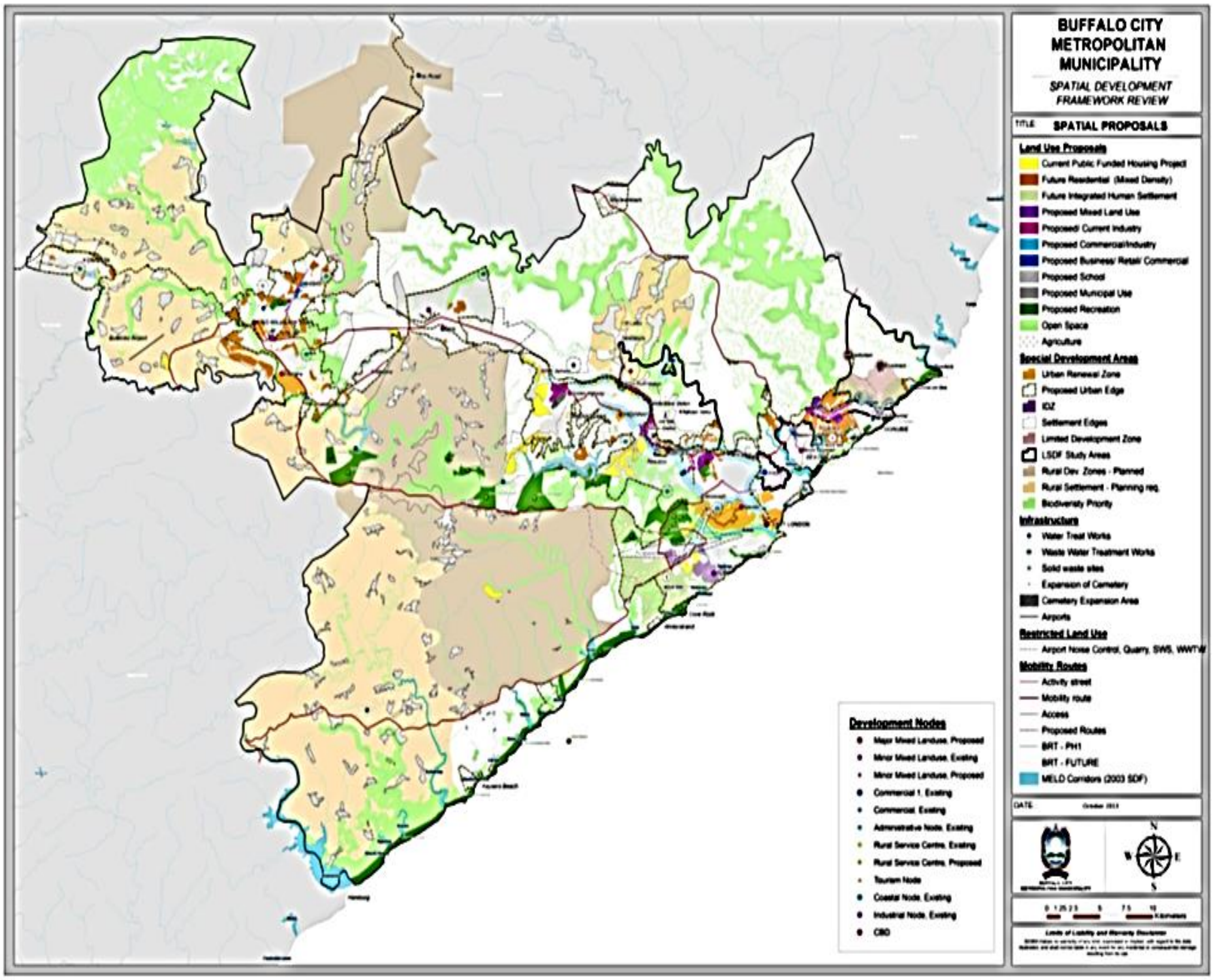


Figure 12 presents the various coastal conservation plans envisioned for BCMM. These proposals include land use proposals (such as proposed land uses for the municipality, recreation, open space, agriculture, commerce, and so on); the special areas for proposed coastal conservation development (such as zones for urban renewal, proposed urban and settlement edges) infrastructure (such as solid waste sites, cemetery expansion, and so on) and proposed mobility routes. Also, the current and projected housing projects are highlighted in the image (as yellow and red polygons), while the proposed mixed land use and commercial industries are depicted as purple and blue polygons. Further, the SDF also incorporates the need for recreation and green areas (which are highlighted in different shades of green respectively). It is also imperative to state that any positive venture will manifest challenges along the path of implementing coastal vegetation conservation laws.

4.4 GENERAL IDP AND SDF STRATEGIES FOR BCMM SPATIAL PLANNING

The BCMM IDP and SDF expound distinct policies for the purpose of managing spatial development and land use in accordance with guidelines for the spatial development of the study area, and these are geared towards the actualization of the development vision as entrenched in the BCMM SDF and IDP. The next section discusses the proposed urban space development plan from the year 2015-2025, as highlighted in the SDF document.

4.5 THE PROPOSED SDF URBAN SPACE DEVELOPMENT

In a bid to actualize the dream of a compact city for BCMM, the concept of the urban edge was incorporated into the SDF of the study area, so as to combine efforts aimed at consolidating the urban areas. It is on this premise that the SDF recommend an urban edge be established in such a way that it will have a “trickling down effect” of development on rural development, thereby favouring the latter (BCMM Report, 2017). Further, the urban edge incorporates the prevailing urban components as well as the close surrounding areas within the study area, with the overarching aim of intensifying infrastructural development, and thereafter yield higher concentrations of housing, manufacturing, commercial and industrial development (BCMM Report, 2017). Outside the urban edge, it is envisioned that the rural areas will be equipped with basic infrastructure and social amenities. The demarcation of an urban edge is imperative for the control of urban sprawl, to incorporate urban areas and strengthen development. In a nutshell, the urban spaces function as a restriction to urban sprawl, protection of essential resources and environments, densify built-up areas; reorganize trends in development, reposition growth prospects, and justify their efficiency as areas of service delivery. Specific areas within and beyond urban spaces in the study area have been recognized as ‘Limited Zones of Development’, which are largely referred to as sensitive environments typified with low development intensity, and act as buffers between the rural and urban communities (Cilliers, 2014). Figure 13 represents the envisioned urban space development plans for the study area.

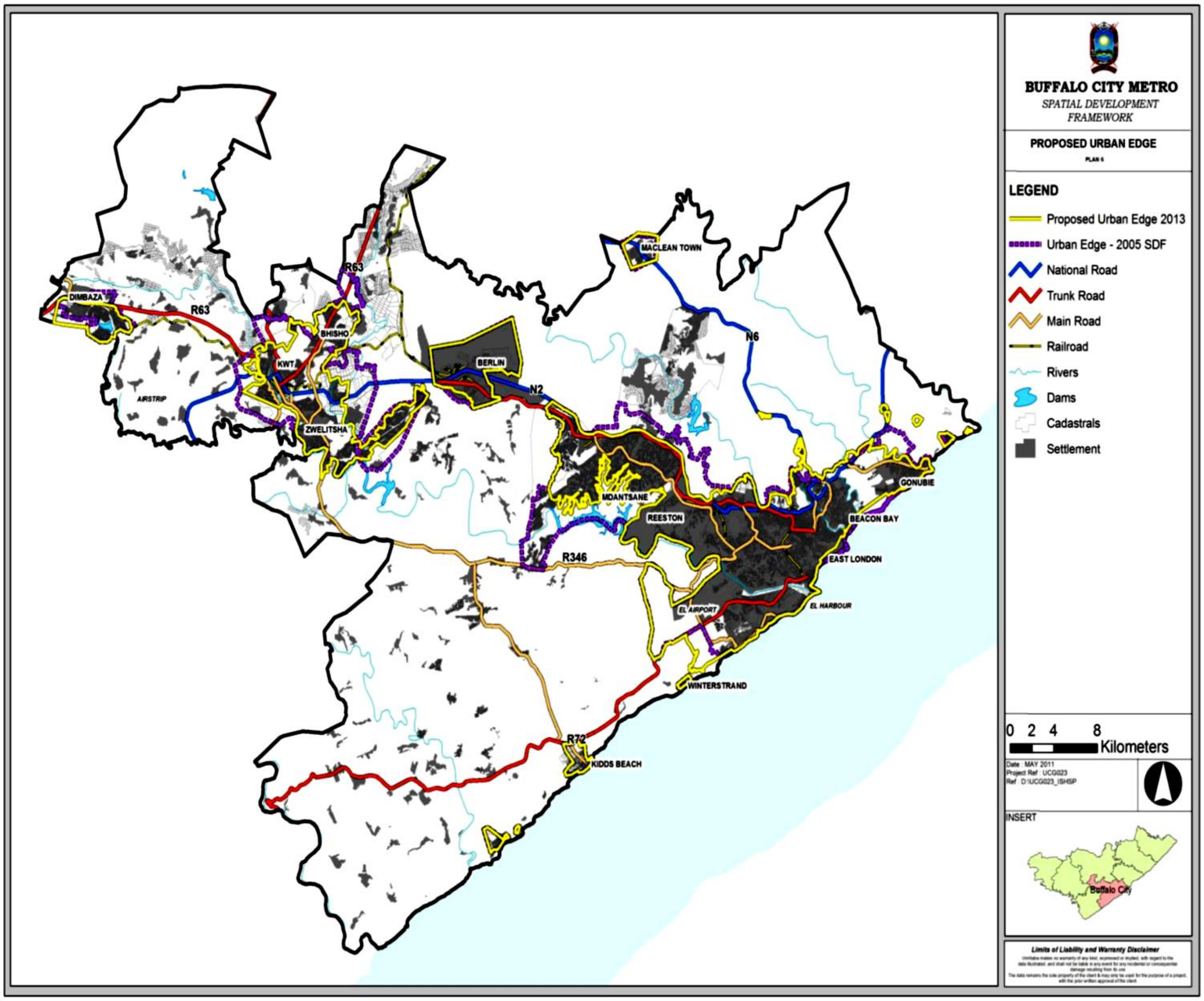
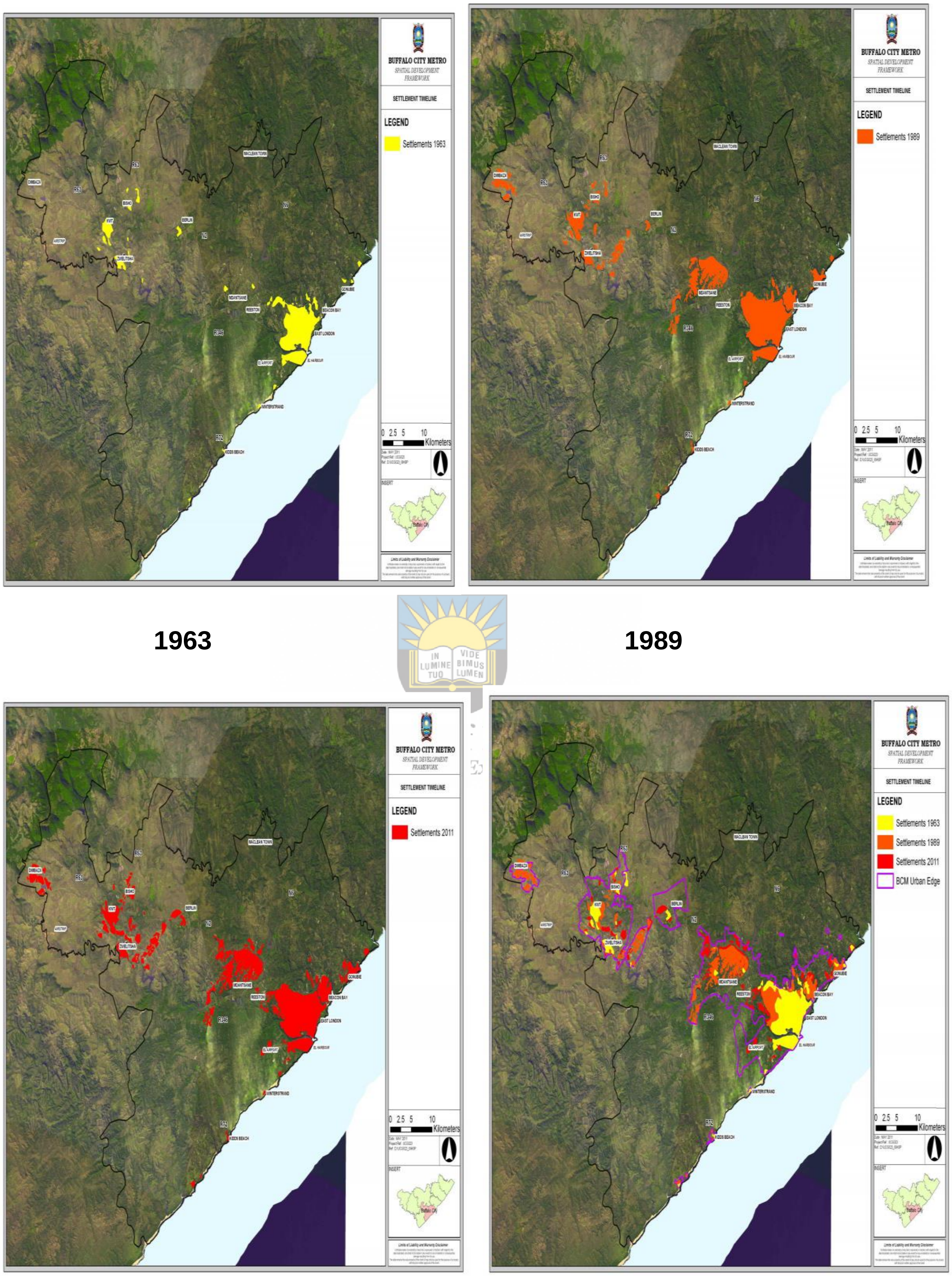


Figure 13: The Study Area Depicting Urban Space Development Plans (Source: BCMM Report, 2017)

Figure 13 depicts the 2005 and latter urban space development plans as incorporated in the SDF document. The Figure depicts an extension of the urban edge boundaries in communities such as Bhisho, Zwelitsha, Dimbaza, Berlin, Mdantsane and Summerpride, West Bank, Gonubie and King Williams Town, which depicts the original SDF 2005 urban edge, and the newly projected urban space is presented in yellow colour, so as to easily distinguish the difference. The newly projected urban edge was envisioned due to the expansion of development and hitherto population pressure experienced in the aforementioned areas.

4.6 THE DEVELOPMENT OF URBANIZATION AT BCMM

This subsection discusses how the urban sector in BCMM has evolved for over 50 years (from 1963 to 2017), which is characterized by rapid spatial urban development, as well as providing a platform for evaluating the phases of spatial urban development that conceptualizes the pre-apartheid to the post-apartheid era in the study area. From the foregoing, spatial urban development in the study area has advanced in service delivery and infrastructural development in the period under review. The year 1963 was characterized by uneven spatial development, and the major area that was urbanized was East London and Beacon Bay with some features of residential buildings and so on. Other areas that had very few infrastructural facilities (such as residential buildings, roads and rails, and so on) were Zwelitsha, Bisho and Berlin (BCMM Report, 2017). The year 2011 witnessed a further increase in spatial urban development around East London, Beacon Bay, KWT, Zwelitsha, Bisho, Berlin, Gonubie and Dimbaza. Figure 14 reveals the level of urban expansion and urban edge in the study area from 1963- 2017.



1963 **1989**

2011 **2017**

Figure 14: Urban expansion at BCMM in 1963,1989, 2011 and 2017 respectively **(adapted from: BCMM Report, 2017)**

4.7 IMPLICATIONS OF THE IDP AND SDF ON THE SPATIAL DEVELOPMENT OF BCMM

According to BCMM Report, (2017) and Keyser, (2018), the implication of the IDP and SDF policy framework on the metro municipality as regards sustainable urban development include the following: The IDP and SDF have made significant provisions for environmental/ecological challenges and sensitivities over the years within the implementation of strategic spatial and land-use change planning and decision-making processes. Secondly, both policies have led to the development of spatial planning in the study area (Ruwanza, 2016). Thirdly, the documents clearly state the importance of strategic spatio-environmental representation towards future planning and guidance towards ecological conservation projects and investments (Cole,2019; Nel, 2019). Additionally, the IDP and SDF policy framework has contributed to the actualization of more comprehensive integrated strategies towards planning and development in the study area. Conclusively, both documents have advocated for the management of some planning initiatives such as ecological conservation, spatial planning, land-use planning/development, through integrated development planning strategies (Monkam, 2014; Marais, 2016; Agyepong, 2017).

4.8 A CRITIQUE REGARDING THE PERFORMANCE AND IMPLEMENTATION OF SDF AND IDP COASTAL BIODIVERSITY CONSERVATION POLICIES AT BCMM SINCE THE POST-COLONIAL ERA

Despite the positive contributions of the SDF and IDP spatial policy framework, to the development of BCMM, it is empirically evident that there is a lack of visible implementation of the biodiversity conservation policies in the SDF and IDP documents, resulting in uncontrolled anthropogenic interventions such as unmonitored urban expansion activities, which is, still largely uncontrolled (Kuruneri-Chitepo, 2011; Ruwanza, 2016). Hence, according to Berrisford, (2011); Olson, (2013); and Chishaleshale, (2015), this has adversely culminated in the reduction in coastal vegetation and wildlife species overall quantity and ecosystem diversity; disruption of biogeochemical cycles and CVEs scenic beauty; increase in soil erosion and reduced soil precipitation, and the gradual disappearance of wildlife habitat. Other environmental hazards, (as epitomized by Manyefane, 2014; Ruhiiga, 2014), resulting from the non-implementation of the SDF and IDP biodiversity conservation policies include: increase in the quantity of atmospheric carbon, due to the reduction in the quantity of sequestered carbon. Other examples include the reduction in microbial population and basal respiration activities in the soil; increase in the incidence of pests and diseases; alteration of the micro-climatic conditions of the study area, among others (Harrison, 2013; Gwedla, 2015). From the foregoing, Ruhiiga, (2014); David, (2018); discussed typical examples of non- implementation of the SDF and IDP conservation laws in the coastal areas of Nahoon Nature Reserve and Quigney Business District, which are characterized by uncontrolled urban expansion; leading to encroachment into CVEs in these areas. These have further culminated in the reduction of the ecological functioning of goods and services (Ruwanza, 2016); as well as the loss of coastal habitat for endangered plant species and wildlife, and reduction of soil microbial activities in those areas (Monkam, 2014; Manyefane, 2014; David, 2018).

4.9 CONCLUSION

This chapter focused extensively on a critical evaluation of the Integrated Development Plan and the Spatial Development Framework of BCMM, which is the foremost document channeling all administrative actions of the study area. Further, the SDF and IDP policy framework mirrors the desires of the inhabitants, which is premised on the human and capital resources of the metro municipality. The role of the SDF policy framework in ensuring the spatial development of the metropolitan area cannot be under-rated, as it is the documentation of the viable and sustainable ways of channeling the socio-economic requirements of the BCMM people to improve their living conditions. In line with the aim of this research, which centers on urban expansion, CVEs, and conservation in BCMM, the IDP and SDF policy framework has significantly enhanced the spatial development of the former BCMM apartheid space, (which was characterized by spatial segregation and fragmentation of white and black communities and services), into a more efficient, productive and spatially balanced metropolitan area. Further, the functioning of ecosystems goods and services have improved on account of the entrenchment of the IDP and SDF policy framework of the study area, and this is elucidated in the subsequent chapter, which unraveled the second study objective of this thesis on ecosystem functioning, goods, services and economic benefits in BCMM. On the other hand, the urban coastal areas have witnessed vegetal losses because of the non-implementation of the biodiversity conservation policies, as well as the establishment of development nodes and extension of urban edges, as recommended by the IDP and SDF policy framework. For example, urban expansion has greatly degraded the fragile CVEs in the study area; most especially around the Nahoon Nature Reserve, Quigney. This observation conforms with research results derived in subsequent chapters regarding coastal vegetation loss attributable to urban expansion. It is on this premise, therefore, that this study emphasizes the urgent need for local authorities to monitor and ensure strict compliance with biodiversity legislation and conservation policies geared towards the sustainability of coastal ecosystems functioning in the study area.

CHAPTER FIVE

THE CONSERVATION OF OBTAINABLE ECOLOGICAL GOODS, SERVICES AND ECOSYSTEMS FUNCTIONING

5.1 INTRODUCTION

This chapter contains data presentation and discussion of the findings based on the broad and specific objectives of the study. The core argument of this chapter is centered on the urgent need to assess, manage, evaluate and monitor ecosystem goods, services and their economic benefits BCMM. Hence, the conservation of ecosystem goods, services and their economic benefits are of particular importance to ecologists, administrators, policy makers and other stakeholders for purposes of enhancing planning, administration and conservation efforts, as well as making an informed judgment and conclusion in this study. [2] The theoretical framework used in this study is hinged on the Urban Green Sustainability (UGS) Theory. The presented findings in this chapter argue that the UGS Theory influences ecosystem functioning as well as the conservation of ecosystems goods and services in the study area. Further, UGS Theory stimulates ecosystem health and resilience to consolidate efforts on biodiversity conservation and enhance ecosystem services in the fragile BCMM Coastal Vegetation Environments (CVEs) (Jennings, 2016). Furthermore, 5 research hypotheses were explored to determine the correlation between

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Olatoye, T.A.; Kalumba, A.M; Mazinyo, S.P; and Odeyemi, A.S. (2019): Ecosystem Functioning, Goods, Services and Economic Benefits in Buffalo City Metropolitan Municipality (BCMM) Eastern Cape, South Africa. Published in the *Journal of Human Ecology, India. REF. NO. JHE-038-19* DOI: 10.31901/24566608.2019/ ISSN 2456-6608 knowledge of biodiversity conservation and ecosystem functioning/services provision. The unique knowledge of biodiversity conservation (the independent variable X) was measured on ecosystems functioning (the dependent variable Y). Hence, the correlation and binary logistic regression analysis were used in analyzing the relationship between the two aforementioned variables. The technique is supported in the literature by Levavaseur, (2013) and Liu, (2013).

5.2 THE MAIN PURPOSE OF THE CHAPTER

The main purpose of this chapter stems from the fact that there is inadequate information regarding ecosystems functioning vis-à-vis the obtainable goods and services in BCMM CVEs. It is on this premise that the main purpose of this chapter is hinged on providing information on the assessement and inventory of ecosystems goods and services which are available in the study area. However, these eosystems goods are largely degraded, endangered and depleated on account of several anthropogenic factors such as urban expansion, minning, deforestation, in addition to other natural causes such as climate change. It is on this premise that this chapter further makes a clarion call for urgent measures geared towards the monitoring and conservation of these scarce resources in the municipality's CVEs, which the UGS Theory promotes. it is also essential to state that the analysis of research findings correlates with the chapter's core argument, as elucidated in the sections on research findings in subsequent sections in the chapter.

Urbanization, especially in coastal areas poses threats to these fragile ecosystems; which compromises their functioning and services provision in the environment and community at large. Despite the numerous benefits accruing from CVEs [such as biodiversity conservation (Mace, 2012; Bommarco, 2013; Breuste, 2013); carbon sequestration (Egoh, 2012; Reyers, 2012); and defense against soil erosion (Mendoza-González, 2012; Ninan, 2012). Further, vegetation beautifies the environment (Reyers, 2012; Rao, 2015; FAO, 2016), flood control (Sitas, 2014), desertification and water supply (Wangai, 2016; Turpie, 2017); ecosystem goods and services, have been greatly hampered in BCMM (Cilliers, 2014). This calls for continued research to be undertaken, monitoring, and protection to ensure ecosystem functioning and services which is fundamental in coastal green sustainability (Willemen, 2013; Cortinovis, 2018). According to Bastian, (2012), there are two basic areas of ecosystem functioning, firstly are the functions which offer a direct advantage to man and secondly the environment. These are those, which uphold natural systems integrity in general and ecosystems in specificity (Cabello, 2012). Also, the classifications of functions (namely information, habitat, production and regulation functions by Egoh, (2012) was elucidated in this chapter. This chapter also focused on the analysis of Section D of the questionnaire, which relates to BCMM ecosystems functioning of goods and services. From the foregoing, 300 copies of the questionnaire were distributed to the respondents, of which 254 copies (84.7% participation rate) were returned. The analysis of results begin with the data respondents demographic characterization (such as age, educational attainment and race); as well as other issues including the following: knowledge and benefits derived from CVEs; changes in features of CVEs and conservation, as well as the analysis of derivable services (such as provisioning, cultural and regulation services) in the study. This chapter also presented an analysis of seven (7) research hypotheses, which proved the relationship between knowledge of ecological conservation and coastal ecosystems functioning. These were analyzed through the binary logistic regression technique in SPSS software to determine the Odds Ratio, p values, Confidence Interval (CI, at 95% levels of significance), as well as Hosmer and Lemeshow's Chi-Square (χ^2) statistics (Pallant, 2001), and all the hypothesized postulations depicted high levels of significance. In the urban scene, for example, the significance of ES cannot be over-emphasized. For example, Elmqvist (2015), posited that financing, restoring, conserving, and improving ecosystem services and green infrastructure in urban climes goes beyond its social or ecological values, as well as being economically sustainable. Further, the applications of ES is vital in decision-making procedures associated with urban land use and management practices and to guide restoration practitioners and landscape planners, in the course of environmental service delivery (Jorda-Capdevila, 2016). Although economic considerations provide worthwhile arguments for environmental developments, they are inadequate to fully measure, capture or monitor the wide array of merits associated with urban ecosystem services restoration. Indeed, many significant ecosystem services were not acknowledged in some published works on economic valuations of urban green infrastructure, other merits considered in this chapter incorporates benefits such as promoting well-being, provisioning services, and social comfort, as further research efforts are required to satisfactorily capture these values. Urban ES are produced in diversities of habitats, green spaces, urban forests parks, vacant lots, landfills; cemeteries, gardens and yards, blue spaces, campus areas, and including streams, lakes, ponds, artificial swales, and storm water retention ponds (Chen, 2014; Elmqvist, 2015), and are generally typified by high demand on account of a very large number of immediate local beneficiaries. At this juncture, it is imperative to state that the study area enjoys certain ES benefits in areas of forestry and agriculture. In the study area been reviewed, there is a preponderance of native forests and plantations along with the Amatola mountain range from Keiskammahoek to Stutterheim extending towards King William's Town, as well as coastal vegetation along the coastal area of East London. In addition to the ecosystem benefit of abundant forest resources, the study area is also blessed with landmass for potential agriculture (BCMM Report, 2017). Further, there is a stretch of vast land suitable for forestry in Gonubie and environs. Other intensive agricultural lands are scattered around locations such as Mdantsane, Dimbaza, Bisho, KWT, just to mention a few. The other derivable benefits from the study area are presented as results from the survey conducted among different groups of persons in the study area, and these are elucidated in subsequent sections in this chapter. The subsequent section discusses the data respondents characterization.

5.3. RESEARCH FINDINGS

This section analyses the research findings analyzed on ecosystems functioning as well as goods and services provisioning. The results of the findings are illustrated in tabular and graphical presentations, and the results are supported with the theoretical and empirical literature.

5.3.1 Knowledge of Coastal Vegetation Resources and the Environment

The study also investigated the respondents' knowledge of coastal vegetation resources. This is because these two aforementioned underpinnings revealed whether the respondents were knowledgeable about coastal vegetation conservation in the study area. Hence, the research findings from this exercise below, provide answers to questions 5 and 6 of the questionnaire. Figure 15 depicted below reveals the level of knowledge of the respondents towards coastal vegetation resources and the environment. The figure reveals that while 144 respondents (56.9 %) have knowledge of coastal resources and the environment, while 77 respondents (30.4%) still claim ignorance of the significance of ecological resources, hence, this thesis is long overdue, as urgent strategies towards the orientation of the populace on the importance of conserving CVEs and environmental resources should be expedited. Figure 15 presents the percentage of responses regarding knowledge and care for coastal vegetation resources.

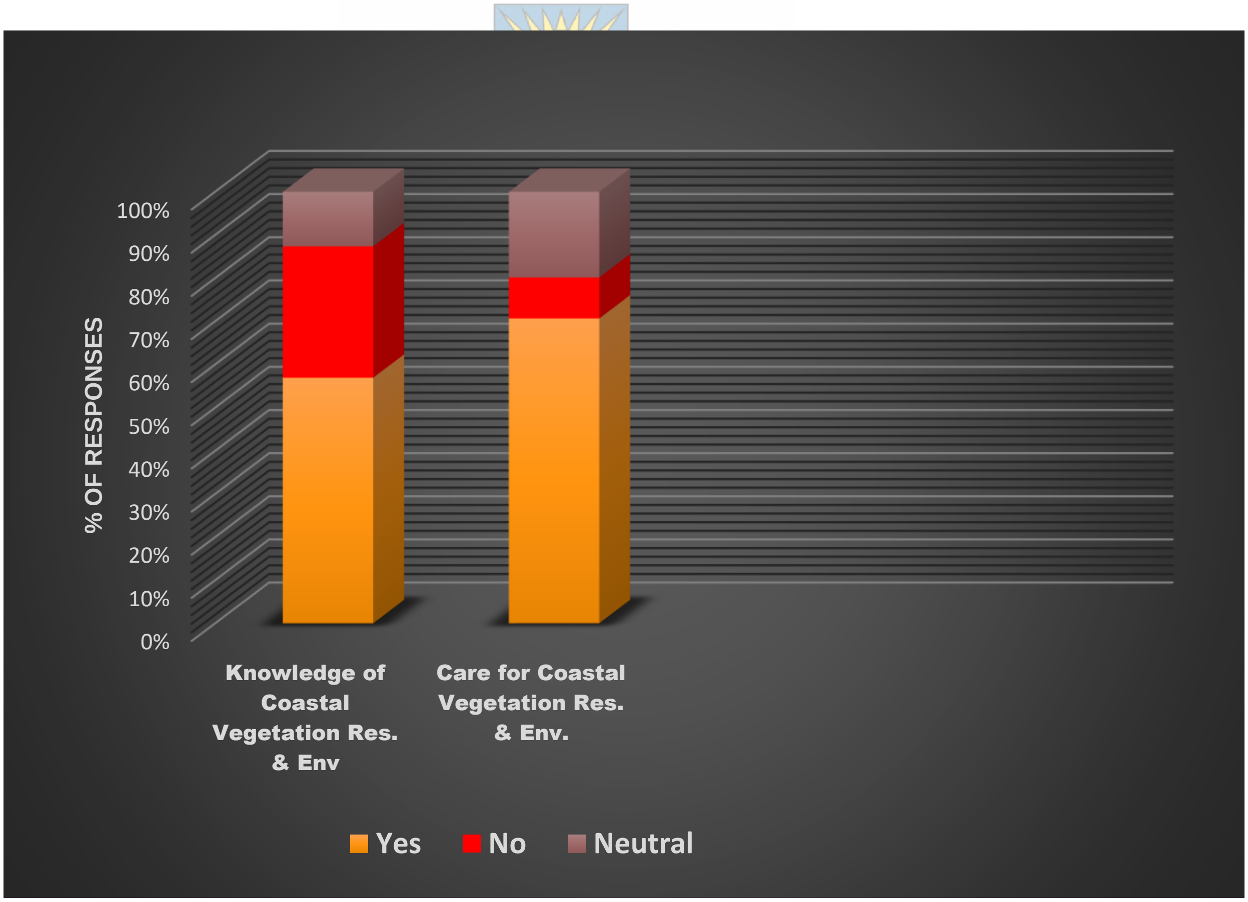

Figure 15: Responses on Knowledge of Coastal Vegetation Resources

5.3.2 Benefits Derived from Coastal Vegetation Environments (CVEs) in the Study Area

The benefits which the BCMM dwellers derive from their CVEs were analysed. From the foregoing, Figure 14 reveals the benefits that the surveyed respondents derive from CVEs. It depicts that 159 (62.8%) of the respondents derive medicinal benefits such as herbs for the treatment of ailments and diseases such as measles, hypertension and insomnia. This is buttressed by Wintola (2015), who stressed that *Hypoxis hererocallidea*, *Strychonos henningsii*, *Rumex lanceolatus*, *Ozoroa mucro nata Acacia karoo, Cotyledon orbiculata*, among others are available in the study area for medicinal purposes. Also, 154 respondents (60.9%) were of the perception that the study area provided raw materials for cloth-making, pharmaceuticals, shoe accessories, and so on from the CVEs, while and 161 respondents (63.4%) stated economic benefits respectively. Also, 159 respondents (62.8%) indicated that economic benefits were obtainable from BCMM's ecosystem. From the foregoing, the researcher observed during field work that diverse raw materials were utilized in clothing-making and fashion-based factories, timber (for furniture and carving).

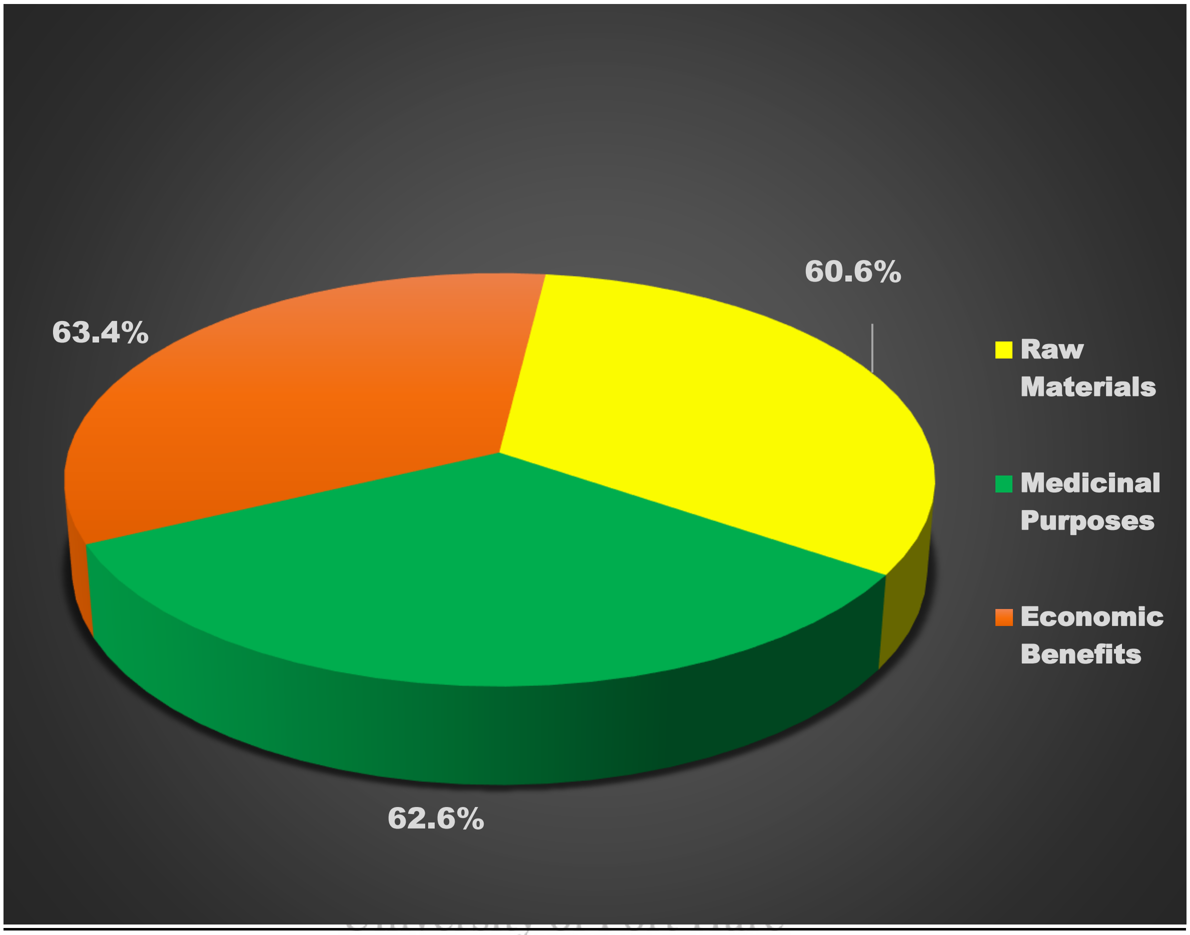

Figure 16: Benefits derived from Coastal Vegetation Environments at BCMM

5.3.3 Changes at BCMM Coastal Vegetation Environments (CVEs)

The study also sought to analyse the changes in CVEs in the study area on account of the anthropogenic influences, resulting in alterations in the quality and quantity of coastal vegetation resources, resulting in the removal of coastal vegetal cover as well as environmental degradation (Hagen, 2010). The research findings revealed that a total of 119 respondents (48.0%) further confirms that the overall quality had changed, 41 respondents (16.5%) stated that the species abundance had been altered, while 53 respondents (21.4%) stated that there were changes in the diversity of the ecological system in the study area (on account of their native knowledge and ecological training). This is presented in Figure 17.

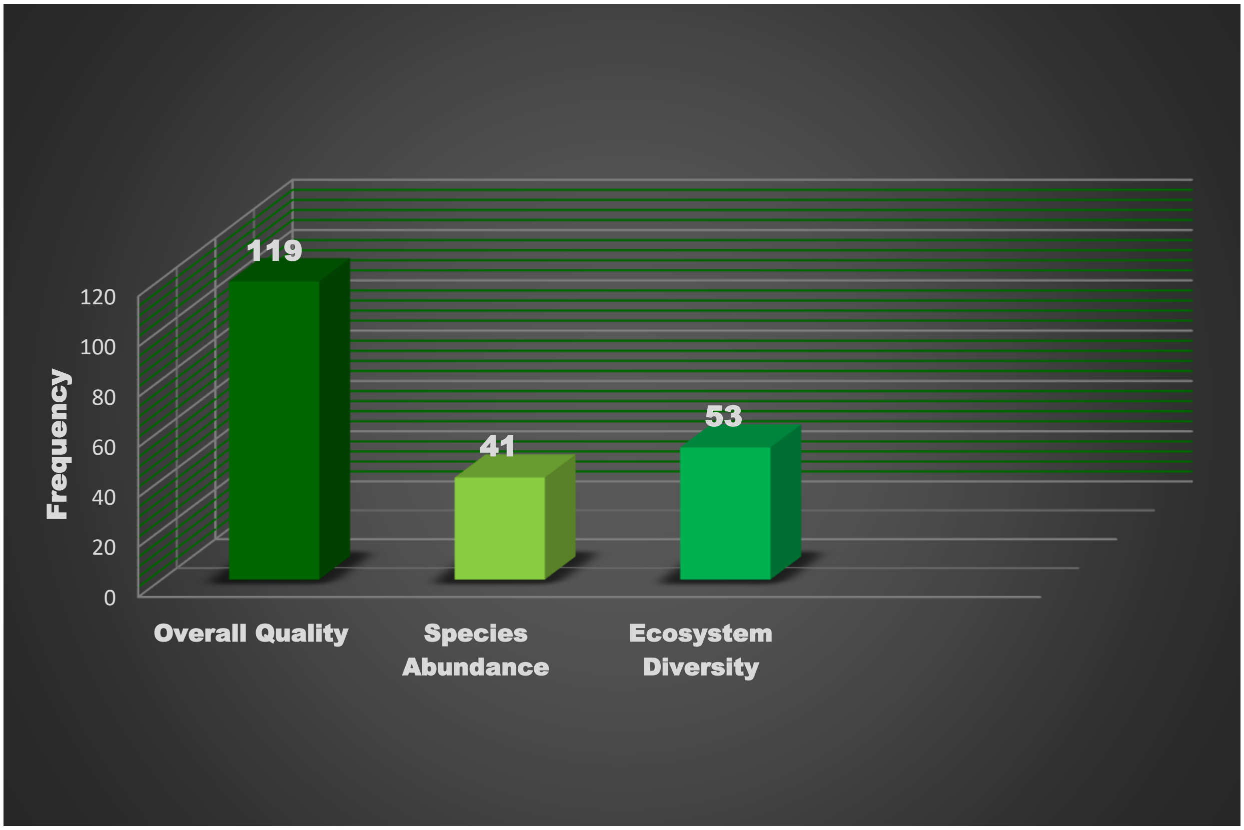

Figure 17: Changes in Features of Coastal Vegetation Resources at BCMM

5.3.4 Nature of Coastal Vegetation Changes in the Study Area.

The researcher studied the nature of changes in the BCMM CVE, and the result revealed that 179 respondents (72.5%) were of the perception that there is a decline in CVE resource base, and this assertion is in conformity with existing literature, such as Dearborn, (2010); Syphard, (2011); Egoh, (2012); Fu, (2013); Ferreira, (2016). The reasons deduced in order of importance include urban expansion and natural factors such as climate change, and this is supported in the literature by Turok, (2012), Mbolambi, (2016). Also, 12 respondents (4.9%) asserted that there were no changes, and 29 respondents (11.7%) reported increased change. The decreased change is attributable to the removal of coastal vegetation through deforestation, degradation and natural causes on account of urban expansion, while increased change is positive change due to reforestation strategies geared towards CVE conservation. This is presented in Figure 18.

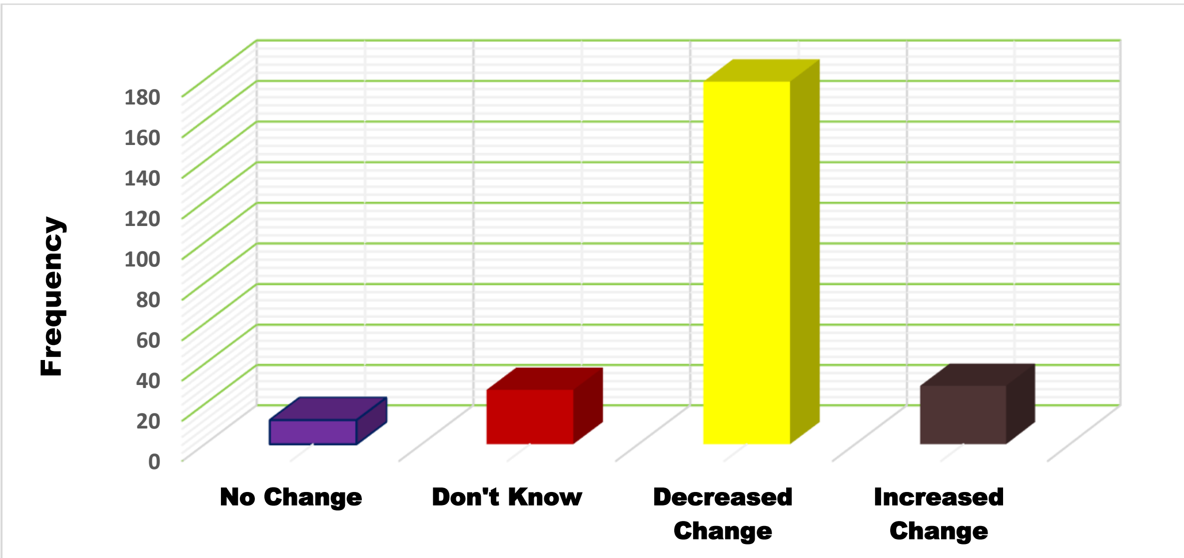

Figure 18: Perception of Respondents on the Nature of Coastal Vegetation Change in the study area

5.3.5 Assessment of Coastal Vegetation Resource Management and conservation in the Study Area.

The respondents were required to rate the level of coastal vegetation conservation in the study area on a scale of 1 to 10 (1= extremely poor CVE conservation; 10= Excellent CVE conservation). The outcome is tabulated in Table 4.

TABLE 4: ASSESSMENT OF COASTAL VEGETATION RESOURCE MANAGEMENT AND CONSERVATION IN THE STUDY AREA

Rating	Frequency	Percentage (%)
Extremely poor CVE conservation (1)	30	12.6
2	25	10.5
3	27	11.3
4	25	10.5
Average CVE conservation (5)	52	21.8
6	37	15.5
7	21	8.8
9	0	0
Excellent CVE conservation (10)	8	3.3
Total	**239**	**100**

Table 4 reveals the level of CVE conservation for medicinal, economic and cultural purposes at BCMM. The results indicate that 52 respondents (21.8%) rated the conservation of coastal vegetation resources as average (rating of 5), while the second highest rating of 37 respondents (15.5%) were of the perception that conservation efforts were above average, and 30 respondents (12.6%) gave a poor rating regarding the conservation of CVEs in BCMM. This necessitates that urgent steps must be taken to address unsustainable environmental management practices such as uncontrolled urban expansion, massive deforestation and selective logging of timber species.

5.3.6 Obtainable Ecosystem Goods and Services in the Study Area.

The obtainable ecosystem goods and services in the study area are categorized into three types namely :

a) Provisioning Ecosystem Services

b) Cultural Ecosystem Services; and

c) Regulation Ecosystem Services.

The three aforementioned types of ecosystem services provided by BCMM are analyzed below respectively.

5.3.7 Provisioning Goods and Services at BCMM

This section deals with the provisioning goods and services that are available in BCMM, and it is in response to question 17 a, b and c, and have been grouped into provisioning, cultural and regulating functions correspondingly. Figure 19 below refers to the provisioning services provided in BCMM, which is in response to the seventeenth question (Number 17a) of the questionnaire. Out of a total of 254 respondents, those who confirmed the availability of timber and pines were 51.2% and 32.8% correspondingly, and this was confirmed by the researcher in the process of field observation, for example, some species of *Tectona grandis* were seen in parts of Schornville, Gonubie and Zwelitsha, while *Pinus caribaea* was available in areas such as King Williams Town, East London and Mdantsane. Further, 146 respondents (57.5%) asserted the presence of medicinal plants, and these species were confirmed by Petrouska, (2012); Wintola (2015); to be found at BCMM, Hypoxis *hererocallidea*, *Strychonos henningsii*, *Rumex lanceolatus*, *Ozoroa mucro nata Acacia karoo, Cotyledon orbiculata. The*se medicinal plants provide chemicals that can be used as herbs and pharmaceuticals (Choudary, 2011; Lahlou, 2013). Also, the study area is known to be a haven for genetic resources, as 104 (40.9%) respondents laid credence to this. A major advantage of genetic research is that many biotic components which were formerly obtained in the wild are now acquired from cultivated flora and domesticated fauna species in the study area (Larson, 2014). In order to maintain the output of these cultivars, the genes of the species are modified to harness certain qualities such as taste, improved resistance to pathogenic disturbances, as well as the ability to adapt to certain environmental conditions (Mannion, 2012; Shanks, 2015; Yohannes, 2017; Olatoye, 2019). A graphical expression of the provisioning services in the study area is presented in Figure 19.

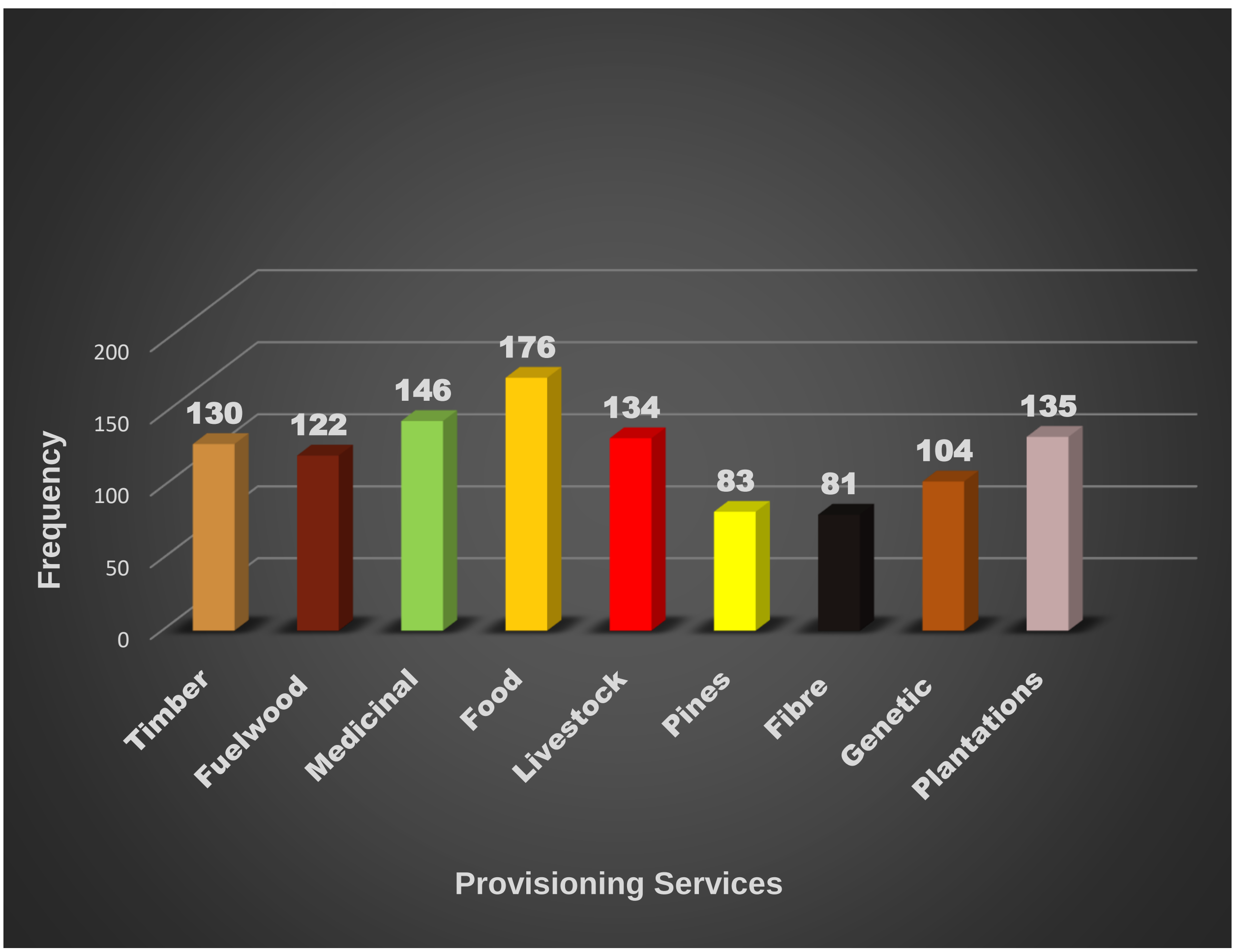

Figure 19: Provisioning Ecosystem Services at the Study Area

Figure 19 reveals that 176 respondents depended on the BCMM ecosystem for the provision of food, and this is sufficient evidence since the respondents were above average (69.3%). Further, the cultivation of beans and maize on several acres of land around the CVEs of East London and immediate environs, thereby confirming the research results in the study area. These include edible plants/vegetables such as *Spinacia oleracea* (spinach) and poultry such as chicken and turkey. Others include beef, mutton, pork, dairy products, as well as fruit processing such as *Mangifera indica* (mango), *Pyrus malus* (apples), *Musa paradisicum* (banana), *Citrus limon* (lemon), *Citrus hystrix* (lime), as well as cereal grains such as *Zea mays* (maize), and East London factories for the processing of animal-feed (such as grass, leaves, krill). Also, there is a preponderance of subsistence farming practices in several commercial areas and private residences around King Williams Town, Zwelitsha, Dimbaza, Gonubie, Vincent and Quigney. The next sub-section discusses the cultural services available in the study area.

5.3.8 Cultural Ecosystem Services Available in Study Area

Cultural ecosystem services provided in the study area include ecotourism, traditional knowledge, cultural heritage and religious services. Similar studies by Hagen, (2010) confirms the availability of ecotourism and cultural heritage services in the study area. The cultural ecosystems services of BCMM is presented in Figure

20.

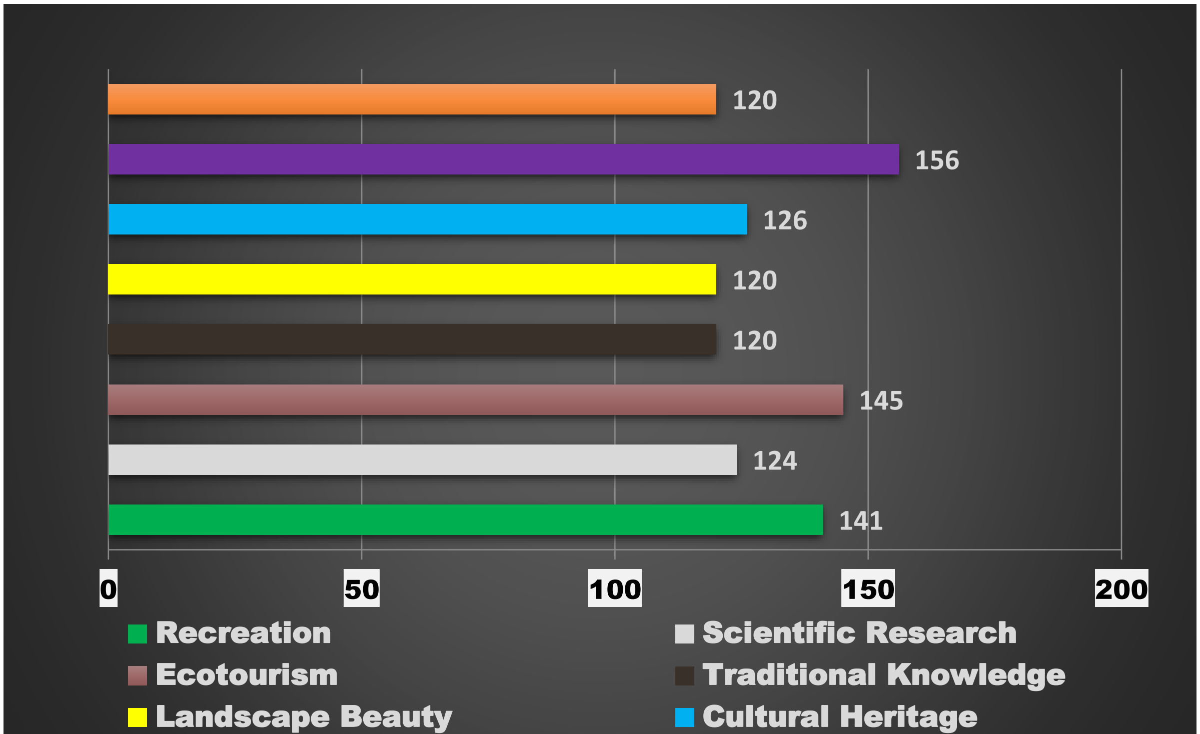

Figure 20: Cultural Ecosystem Services Provided by BCMM Ecosystem

5.3.9 Regulation Ecosystem Services Available in the Study Area

These refer to the cultural ecosystem services provided in the study area namely Erosion control, hydrological regulation, climate regulation, soil/water/air purification, waste treatment, flood buffering, habitat maintenance, carbon sequestration and coast stabilization functions. The research findings indicate that 129 (50.8%) respondents affirmed air quality regulation function of the study area. According to Bommarco, (2013), life on earth exists on account of the balancing of air quality in the atmosphere and vegetation, and any alterations in that balance can positively or negatively affect natural as well as economic and social processes. It is also important to note that biogeochemical procedures regulate the chemical configuration of oceans and the atmosphere, and these are concomitantly influenced by many ecological components of natural ecosystems (Burkhard, 2012), and vital examples include the effects of ecological components on processes which ensure the regulation of carbon dioxide/oxygen atmospheric balance, and the maintenance of the ozone-layer. Further, the respondents that indicated in favor of climate regulation functions were 129 (about 50.8%). According to Ziervogel, (2014), the regulation of climate and local weather are hinged on the complex activities and multiple interactions of regional and global circulation patterns in association with other environmental attributes sucha as local topography, vegetation, albedo, as well as the configuration of, for example, lakes, rivers and oceans (which are all evident in the study area). Due to the green-house-properties of some atmospheric gases, gas also plays an important role in this function, but reflectance properties of ecosystems are also important in determining weather conditions and climate at various scales (Willemen, 2013). The services provided by this function relate to the maintenance of a favorable climate, both at local and global scales, which in turn are important in respect to human health, crop productivity, recreation and even cultural activities and identity, among others (Redmond, 2014).

Furthermore, 132 respondents (52%) registered the importance of erosion control as a significant ecosystem service provided by the study area, and in conformity to this postulation, Hagen, (2011) indicated that coastal ecosystems prevent ecosystem disturbance. This function relates to the ability of ecosystems to ameliorate natural hazards and disruptive natural events such as catastrophic effects of soil erosion, storms, floods and droughts through its storage capacity and surface resistance; coral reefs buffer waves and protect adjacent coastlines from storm damage. The services provided by this function relate to the safety of human life and human constructions. As regards hydrological regulation functions, 84 (32.9%) responded in the affirmative. According to Reyers, (2012), water regulation deals with the influence of natural systems on the regulation of hydrological flows at the earth surface. This ecosystem function is distinct from disturbance regulation, as it refers to the maintenance of 'normal' conditions in a watershed and not the prevention of extreme hazardous events. Ecosystem services derived from the water regulation functions are, for example, maintenance of natural irrigation and drainage, buffering of extremes in the discharge of rivers, regulation of channel flow of a medium for transportation. A regular distribution of water along the surface is, therefore, quite essential, since too little as well as too much runoff can pose serious problems. In addition, Dominati, (2010), posited that erosion control helps in the maintenance of crop productivity on cultivated lands and the integrity and functioning of natural ecosystems in the study area. A graphical expression of the regulating services provided by the ecosystem of the study area is presented in Figure 21.

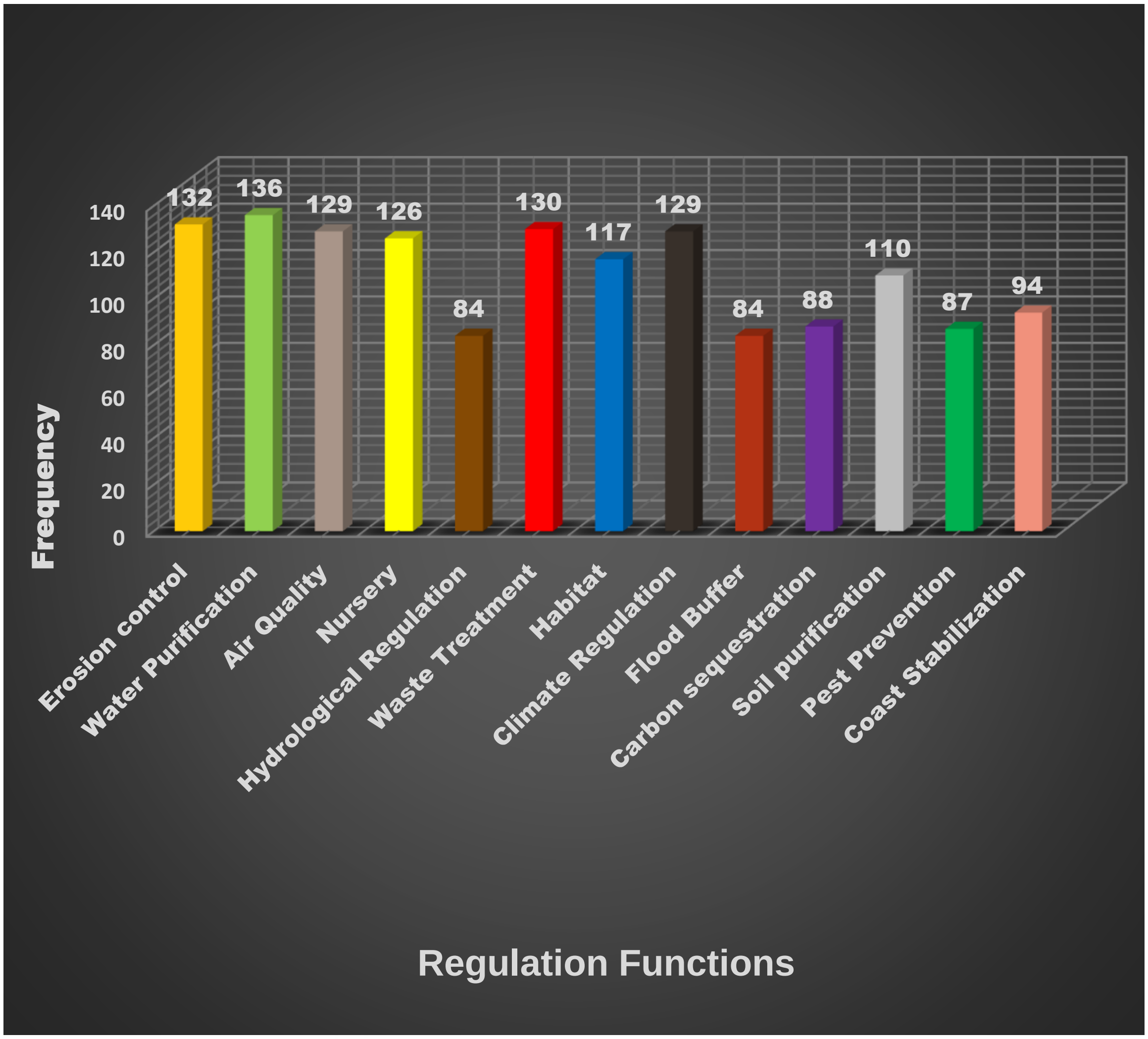

Figure 21: Regulation Functions of BCMM Ecosystem

The significance of water purification as a regulation service performed by ecosystems cannot be under-rated (Percival, 2017), no wonder why 136 respondents (53.5%) indicated in favour of regulation function. This ecosystem function refers to the filtering, retention and storage of water in mainly streams, lakes and aquifers. The filtering-function is mainly performed by the vegetation cover and (soil) biota. The retention and storage capacity depends on the topography and sub-surface characteristics of the involved ecosystem. Furthermore, 126 (49.6%)

respondents mentioned the importance of the study area in serving nursery functions. This is because many ecosystems, especially coastal wetlands, provide breeding and nursery areas to species which when mature, are harvested elsewhere for either subsistence or commercial purposes (Jenerette, 2011). Unfortunately, the nursery services of many ecosystems are often unknown or ignored and in many instances, as nursery areas are, and have been, transformed to other more direct economic uses with disastrous ecological and socio-economic consequences (Hagen, 2010). Also, 130 respondents (51.2%) registered the importance of waste treatment functions which the BCMM ecosystem serves. This is because natural ecosystems can store and recycle certain amounts of organic and inorganic human waste through dilution, assimilation and chemical re-composition (Fabricius, 2015). Forests, for example, filter dust particles from the air, and wetlands and other aquatic ecosystems can treat relatively large amounts of organic wastes from human activities acting as 'free' water purification plants (Haines-Young, 2012). It is also germane to state that 117 respondents (46.1%) mentioned the importance of the BCMM ecosystem as regards providing a safe haven for endangered flora and fauna species, (habitat functions and interrelated services in the ecosystem). This result is consistent with the findings of Cardinale, (2012) Farley, (2012); Gray, (2012) and Fabricius, (2015). The next section analyzes the hypotheses on ecosystems functioning.

5.4 ANALYSIS OF RESEARCH HYPOTHESES ON ECOSYSTEMS FUNCTIONING AND KNOWLEDGE OF ECOLOGICAL CONSERVATION IN BCMM

This section analyses research the hypotheses on ecosystems functioning and knowledge of ecological conservation in Buffalo City Metropolitan Municipality. The focus of Question 21 of the questionnaire, which relates to the perception of respondents' on coastal vegetation resources, provided the platform to analyse this question due to the fact that advocacy for biodiversity conservation measures by inhabitants would be a mirage if the perception of the inhabitants were not assessed. Further, the perception of respondents on CVEs helped to provide data for cross-sectional analysis on the impact of ecological conservation education on ecosystems functioning; and consequently generated seven (7) research hypotheses based on data received from BCMM respondents. The results were determined in the SPSS software (Version 26) environment. These generated hypotheses are central to this study, due to the fact that the knowledge regarding the benefits and functions of ecological systems is central to the conservation of the resource. It is on this premise that the research hypotheses were generated, and are analysed below.

H_{01} – "Ecological conservation education does not positively influence the management of coastal ecosystem goods and services in the study area"

The test for hypothesis 2 reveals that 133 respondents (53.0%) opined that ecological conservation education (X variable) promotes the management of coastal ecosystem goods and services (Y variable) in the study area. Further, the result reveals a p value of 0.545 (which is significant), Odds Ratio value (OR= 0.294), at 95% significance Confidence Interval (CI) of between 0.130 and 0.639, as well as Hosmer and Lemeshow's Chi-Square statistics (χ^2) of 74.579, which is interpreted to mean that respondents who are educated in ecological conservation are 74.579 times more likely to properly manage ecosystems goods and services in BCMM than those who are not. From the foregoing, the null hypothesis is rejected, and consequently, the alternative hypothesis is accepted, which states that *"environmental conservation education positively influences the management of coastal ecosystems goods and services in the study area".* The research hypothesis underscores the significance of being knowledgeable on coastal conservation, this is because ecological conservation education promotes sustainable coastal management practices, and thus enhances the protection of fragile coastal ecosystems in the study area.

H_{02} - "Literacy in ecological conservation does not influence the supply of ecological goods in the study area".

The second hypothesis states that literacy in ecological conservation does not influence the supply of ecological goods in the study area. The result revealed that 129 respondents (51.2%) posited that literacy in ecological conservation (the X variable) promotes the awareness that the supply of ecological goods (Y variable) is a major benefit obtainable from coastal ecosystems, while 91(36.1%) opined differently. Further, the result reveals a p-value of 0.390 (which is significant), as well as Hosmer and Lemeshow's Chi-Square statistics (χ^2) of 38.244, which is deduced to mean that respondents who are well-informed about coastal conservation are 38.244 times more likely to be aware that food provision is a major benefit of BCMM ecosystems than those who are not. From the foregoing, the null hypothesis is rejected, and consequently, the alternative hypothesis is accepted, which states that *“Literacy in ecological conservation influences the supply of ecological goods in the study area”.* This research hypothesis result is consistent with Mustisya, (2016), who oipned that there exists a two-way causal relationship between food security and education. First, food security affects education and health. Further, Headey, (2013) stetd that the probability of being foor insecure devreased by 0.019 for a unit increase in the average years of schooling for a given household. The effect of education remained significant even after controlling for household wealth index, a more proximate determinant of food security in a cash-based economy such as the urban areas. The findings highlight the need to focus on the food security status of the urban poor. Specifically, the results suggest the need for programmes aimed at food provision and enhancing household livelihoods. Also, investment in education of households may, in the long term, contribute to the reduction in the prevalence of food insecurity.

H_{03} - “The identification of medicinal plants is not a function of literacy in ecological conservation”.

The binary logistic regression analysis of hypothesis 3 revealed that 108 respondents (42.9%) stated that medicinal benefit is an important advantage of coastal ecosystems in the study area. Further, the result reveals a p-value of 0.284 (which is significant), Odds Ratio (OR= 0.138), at 95% significance Confidence

Interval (CI) of between 0.139 and 0.482, as well as Hosmer and Lemeshow's Chi-Square statistics (χ^2) of 20.277, which is interpreted to mean that respondents who are acquainted with environmental conservation are 20.277 times more likely to identify medicinal plants of ecosystems in the study area than those who are not. From the foregoing, the null hypothesis is rejected, and consequently, the alternative hypothesis is accepted, which states that *"The identification of medicinal plants* (Y variable) *is a function of literacy in ecological conservation* (X variable)". The results of this hypothesis conform with Mathibela, (2015), who stressed that the global demand for medicinal plants is growing in South Africa. It is also discovered that stakeholders in the medicinal plant's industry who learn to write have the skills to document and safeguard their knowledge of the essential plants. Hence, this will greatly promote the conservation of natural resources at BCMM. Furthermore, this study supports adult learning programmes on the identification and use of medicinal plants. Thus, BCMM inhabitants and graduate students who are proficient in using such medicinal plants may find this impacting positively on their income, as their ability to write will give them the opportunity to document and disseminate their indigenous knowledge themselves, independently of outsiders' input and bias, at their discretion. Further, communication skills acquisition will enhance their ability to collaborate with research and technology organizations, thus enabling them to benefit further from their indigenous knowledge of medicinal plants through publications and intellectual property standards. Additionally, compliance with environmental legislation relating to the collection of medicinal plants is facilitated by being able to read. Hence, this study advocates that knowledge of medicinal plants should be incorporated in school curricula and government policy documents.

H_{04} – "Protection of coastal ecosystem goods and services cannot be harnessed by literacy in ecological conservation".

The binary logistic regression analysis to unravel hypothesis 4 in this chapter revealed that 133 respondents (53.0%) opined that protection of coastal ecosystem goods and services (Y variable) is harnessed by literacy in ecological conservation (X variable) in the study area. Further, the result reveals a p-value of 0.545 (which is significant), Odds Ratio (OR= 0.294), at 95% significance Confidence Interval (CI) of between 0.130 and 0.639, as well as Hosmer and Lemeshow's Chi-Square statistics (χ^2) of 74.579, which is interpreted to mean that respondents who are acquainted about environmental conservation are 74.579 times more likely to protect ecosystem goods and services in the study area than those who are not. From the foregoing, the null hypothesis is rejected, and consequently, the alternative hypothesis is accepted, which states that *""Protection of coastal ecosystem goods and services is harnessed by literacy in ecological conservation".*

H_{05} – "The implementation of coastal ecosystem laws are not advocated by ecological conservation literacy".

The sub-section provides an analysis for the last hypothesis 5, and this was actualized with the operationalization of logistic regression. The result reveals that 85 respondents (33.7%) stated that the implementation of coastal ecosystem laws (Y variable) are not advocated by ecological conservation literacy (X variable) in the study area, while 42(16.7%) gave other reasons. Further, the result reveals a p-value of 0.199 (which is significant), Odds Ratio value (OR= 0.442), at 95% significance Confidence Interval (CI) of between 0.265 and 0.735, as well as Hosmer and Lemeshow's Chi- Square statistics (χ^2) of 10.013, which is interpreted to mean that respondents who are literate in ecological conservation are 10.013 times more likely to advocate for the implementation of coastal ecosystem laws in BCMM than those who are not. From the foregoing, the null hypothesis is rejected, and consequently, the alternative hypothesis is accepted, which states that *"the implementation of coastal ecosystem laws are well advocated by ecological conservation literacy in the study area".* Table 5 below presents the results of research hypothesis on ecosystems functioning and knowledge of ecological conservation.

Table 5: Research Hypotheses on Ecosystems Functioning and Knowledge of Ecological Conservation

Variables			
Gender	**Yes**	**No**	**Test statistics and p-value**
Male	71(28.2%)	51(19.8)	OR= 0.914;95%CI (0.554, 1.508) χ^2=0.123; P= 0.022** df = 1
Female	74(29.4%)	57(22.6%)	
Hypotheses Variables (X)			
Environmental conservation education positively influences the management of coastal ecosystems goods and services in the study area	133(53.0%)	44(17.5%)	OR = 0.294 ;95%CI (0.130, 0.639) χ^2=74.579; P= 0.545**. df = 1
food provision benefit of ecosystems a function of literacy in ecosystems functioning	129(51.2%)	91(36.1%)	χ^2=38.244; P= 0.390** df = 1

The identification of medicinal plants is a function of literacy in ecological conservation	108(42.9%)	50(19.8%)	OR = 0.138 ;95%CI (0.139, 0.482) χ^2 =20.277; P= 0.284**. df = 1
ecosystems functioning literacy determines the awareness that ecosystems provide economic benefits	114(45.1%)	46(18.2%)	χ^2 =34.561; P= 0.370** df = 1
Protection of coastal ecosystem goods and services is harnessed by literacy in ecological conservation	133(53.0%)	44(17.5%)	OR = 0.294 ;95%CI (0.130, 0.639); P= 0.545** χ^2 =74.579
the implementation of coastal ecosystem laws are well advocated by ecological conservation literacy in the study area	85(33.7%)	42(16.7%)	OR = 0.442 ;95%CI (0.265, 0.735) χ^2 =10.013; P= 0.199**. df = 1

5.5 IMPORTANCE OF RESEARCH FINDINGS

Engaging in ecosystem functioning discourse in this study is essential towards ensuring a decent, conducive, livable, efficient and highly productive BCMM. For example, the research findings indicate that 159 respondents (62.8%) derive medicinal benefits for cloth-making, pharmaceuticals, shoe accessories, and so on from the CVEs. Also, 159 respondents (62.8%) indicated that economic benefits were obtainable from BCMM's ecosystem. Regarding provisioning goods, 130 respondents (51.2%) confirmed the availability of timber, while 176 respondents (69.3%) depended on the BCMM ecosystem to feed. It is on this premise that this chapter considered the germaneness of presenting research results from ecosystem functioning and obtainable ecological goods, as well as the economic benefits available from BCMM. The availability of *Tectona grandis*, which were seen in parts of Schornville, Gonubie and Zwelitsha, supports the supply of timber for the furniture industries in other South African provinces, thereby enhancing socio-economic development of BCMM, while *Pinus caribaea adds to the scenic beauty of* King Williams Town, East London and Mdantsane areas where they are found. Further, these flora species act as carbon sinks as well as improving the micro-climatic conditions of the municipality. In addition, the CVEs are environmentally important because they perform erosion control, hydrological regulation, climate regulation, soil/water/air purification, waste treatment, flood buffering, habitat maintenance, carbon sequestration and coast stabilization functions. Furthermore, key ecological services are obtainable from the CVEs, and these include air regulation functions, maintenance of clean, breathable air, and the prevention of diseases (e.g. skin cancer). In a nutshell, BCMM CVEs enhance the general maintenance of a habitable planet. An important issue when trying to determine the service value from this ecosystem function is the scale at which the analysis is carried out. For example, the influence of 1 hectare of ocean, or forest, as a carbon-sink is difficult to measure (Fabricius, 2015). However, the cumulative effect of losing 50% of the earth forest-cover, or 60% of the coastal wetlands, and the reduction of algae-productivity in large parts of the oceans due to pollution, on the gas regulation function is considerable.

5.6 CONCLUSION

This chapter underscores ecosystems functioning, ecological goods, services and economic benefits at BCMM. A synopsis of the entire chapter reveals the types and importance of the ecological systems in the study area. CVEs prevent in excess of 90% of all prospective incidences of diseases from human and crop pathogens. This chapter also presented the analysis of questionnaire results, of which 254 copies were retrieved from different categories of individuals in the study area. The respondents comprised of experts in the fields of science, ecology and biodiversity conservation. Other respondents are officials of the Information Knowledge Management (IKM) Research and Policy Department (which is the department in charge of research in BCMM) , while other respondents are long-term residents and workers in different locations of BCMM (as specified in the methodology chapter), On account of these, their perceptions are considered valid and dependable, and the survey method proved very reliable and suitable for data gathering. This research also sought to know the respondents' knowledge of coastal vegetation resources, as well as the benefits derivable from the study area, and these were categorized into three areas namely: raw materials: 154 respondents (56.9%); medicinal purposes: 159 respondents (62.8%); and economic benefits: 161 respondents (63.4%). Also, the perception of respondents regarding the perception of respondents on the nature of changes in the BCMM ecosystem were analyzed, and the result derived states that 119 respondents (48.0%) acknowledged changes in the overall quality, 41 respondents (16.5%) believed that there were changes in species abundance, while 53 respondents (21.4%) stated that there were changes in ecosystem diversity. Laying credence to this, 179 (72.5%) respondents stated that ecosystem resources had decreased in the study area.

In conclusion,the research findings of this chapter indicates that there are three categories of ecosystem services provided by BCMM CVEs namely provisioning, cultural and regulation services. This chapter also presented five (5) hypotheses which sought to analyse the relationship between knowledge of ecological conservation and coastal ecosystems functioning. Chapter six discusses the influence of urban expansion and coastal vegetation loss in the study area.

CHAPTER SIX

THE IMPACT OF URBAN EXPANSION ON THE CONSERVATION OF COASTAL VEGETATION ENVIRONMENTS (CVEs)

6.1 INTRODUCTION

This chapter analyzes the impact of urban expansion on the conservation of Coastal Vegetation Environments (CVEs) at BCMM. From the foregoing, the Urban Green Sustainability (UGS) Theory is conceptualized for this study because the theory makes a clarion call for sustainable ecosystem management as well as the overall protection of BCMM CVEs (Jennings, 2016). [3] Hence, the presented findings in this chapter underscore the importance of UGS Theory in the conservation of the fragile and endangered biodiverse resource base on account of uncontrolled urbanization that characterizes the study area. This chapter enriches the public with a more holistic conceptualization of urbanization, ecological conservation and the sustainability of cities, and this will concomitantly result in a paradigm shift towards the re-organization and sustainable management of cities in the long run. Secondly, this study serves as an 'intellectual toolbox', which provides the public with the cornerstones for ameliorating environmental challenges in the course of urban development. Furthermore, this chapter provokes academic deliberations amongst geographers, scientists, ecologists, environmentalists, city managers and policy makers at diverse levels by charting appropriate policy directions, strategies,

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programmes, and proactive measures towards the actualization of development in urban areas. Seven (7) hypotheses were presented using the binary logistic regression technique. The knowledge of biodiversity conservation (the independent variable X) was measured on the impact of urban expansion on CVEs (the dependent variable Y), and this is supported in the literature by Levavasseur, (2013) and Liu, (2013). The subsequent section elucidates the main purpose of the chapter.

6.2 MAIN PURPOSE OF THE CHAPTER

The main purpose of this chapter is centered on the fact that the fragile CVEs in the study area are threatened on account of uncontrolled urban expansion. As presented in Chapter seven, about 676.3km^2 of dense vegetation has been lost from 1998 to 2018 at BCMM. This assertion is supported in the literature by Hagen, (2010); Turok, (2012); and Ruhiiga, (2014). For instance, (Cole, 2012), lamented that only a relatively small portion (about 16 hectares) of the over 1500 km^2 Nahoon Point Nature Reserve (NPNR) presently enjoys conservation status, despite being an exceptionally significant green asset to BCMM in general. Furthermore, as part of the implementation of the SDF and IDP policy framework regarding the provision of more accommodation facilities, over 200, 000 units of houses have been constructed and added to the existing ones in several parts of the study area within the past 20 years (BCMM Report, 2017), as well as the construction of roads, airport projects and opening of virgin areas as socio-economic centres of development in various parts of the metropolis. Consequently, this has culminated in the destruction of CVEs for infrastructural development. One of the major reasons for urban expansion in BCMM is rapid growth in population in the study area as recorded in the Provincial Gazette for Eastern Cape, (2014) which reported rapid human population growth in Eastern Cape Province to an alarming rate of 9.2% from 1996 to 2011. Additionally, the present status in terms of extent, nature, at species richness in the study area are unknown due to inadequate information regarding the rate of urbanization and its influence on the BCMM coastal environment. It is on this premise that this study considered very apt, timely and importance of the effects of urban expansion on coastal vegetation ecosystems conservation and functioning in Buffalo City Metropolitan Municipality, Eastern Cape Province, South Africa. From the foregoing, the significance of conserving the fragile BCMM ecosystem should be a major priority of ecologists, decision-makers, administrators and other stakeholders in order to ensure ecological conservation of the study area, as put forward by the Urban Green sustainability (UGS) theory, upon which this study is anchored. Hence, this chapter advocates for urgent procedures and strategies to be expedited towards the protection and conservation of the largely endangered BCMM ecological space. The study involved the distribution of questionnaires to 300 respondents, out of which 123 respondents (41%) are national diploma and university degree certificate holders (refer to Chapter five for distribution of study population). The respondents for this research comprised of experts in the fields of science, ecology and biodiversity conservation. Further, other respondents are officials of the Information Knowledge Management (IKM) Research and Policy Department and workers in different locations of BCMM (as specified in the methodology chapter. Additionally, municipality officials refer to members of staff at BCMM offices in East London and King Williams' Town), while the provincial officials refer to Eastern Cape Development Corporation (ECDC) workers at various offices such as the Department of Water and sanitation, Department of Correctional Services, Statistics SA, all sited at the Ocean Terrance, Moore Street, Quigney, East London. It is also germane to stress that the analysis of research findings correlates with the chapter's core argument, as elucidated in the sections on research findings in subsequent sections. At this juncture, it is imperative to discuss the merits of coastal vegetation, and this is discussed in the next section.

6.3 MERITS OF COASTAL VEGETATION

Coastal vegetation provides a diverse range of ecosystem services vital to human well-being (Bradshaw, 2012; Braat, 2012; Clerici, 2014), and these include the protection of the coastal ecosystem, improvement of water quality, biodiversity support, among others. A great challenge to humanity, most especially the world's poor is the loss of biodiversity in CVEs. It is stated in the literature that over 1.1 billion humans live on less than US$ 1 daily (UNSDSN, 2013; FAO, 2017), and they hinge directly on coastal vegetation environments for their feeding, energy needs, shelter and medical requirements, as well as ecosystem goods and services to sustain their livelihood (Braat, 2012). Consequently, more than half of the world's population (over 3 billion inhabitants) reside around a 100 km radius of a coast, which is less than 20% of all landmass (UNEP, 2016). Also, it is estimated that over 450 million people live around the coastal zones in Sub-Saharan Africa (Kiage, 2013). From the foregoing, pressure resulting from anthropogenic factors in and around coastal vegetation environments (CVEs) has greatly sustained threat to vegetation, wildlife as well as economically important micro-organic resources in most developing societies, South Africa inclusive (FAO, 2011; Amosu, 2012).

It is also elucidated in the literature that CVEs are harbingers of biodiversity, as well as economic activities and leisure (Amosu, 2012). For instance in South Africa, the native vegetation in coastal areas plays a germane role in the stabilization of landscape against wind erosion, in addition to providing wildlife habitation. Further, CVEs play a critical role in the global sequestration of carbon that would otherwise remain as atmospheric carbon dioxide and exacerbate climate change (Duarte, 2010; Kennedy, 2010; Hopskinson, 2012; Dhillon, 2013; Short, 2016). These ecosystems sequester carbon within their underlying sediments, within living biomass aboveground (leaves, stems, branches) and below-ground (roots), and within non-living biomass (such as litter and dead wood). Interest in the role of CVEs in carbon sequestration has increased dramatically over the past several years (Mcleod, 2011). This has led to a corresponding increase in case studies that improve our knowledge of carbon dynamics and the associated biogeochemical processes in CVEs. Such efforts are important in arguing for the protection and restoration of these ecosystems, based on the valuable goods and services they provide, including their carbon sequestration capacity.

The regulation of urban climate and conservation of biodiversity are key ecological provisions of CVEs (Haq, 2011). It is also observed in the literature that in comparison to rural areas, cities experience varying intensities of precipitation and temperature on account of urbanization (Buyantuyev, 2010; Tan, 2010), resulting in urban heat islands due to the high energy use, as well as heat-absorbing surfaces in coastal environments (Stone, 2010; Stewart, 2012; Zhou, 2013). Therefore, sustained coastal vegetation conservation practices and monitoring can help to salvage the situation (Feagin, 2010; Malavasi, 2016). Seinfield, (2012) opined that chemical, biological and particulate materials are known to be key pollutants in CVEs, and these exist in either solid, liquid or gaseous states. Further, urban environments are being at the receiving end of air and noise pollution from vehicles and industries (Haq, 2011), and these are very harmful to the existence of man and the environment (Rojas-Rueda, 2011; Dewan, 2012). From the foregoing, the harmful tendencies of air pollution can be reduced by conserving ecosystems in coastal urban areas (Niemela, 2010; Gaston, 2012). It has also been revealed through research that air pollution can be filtered for more than 70% in CVEs (Williams, 2013). Consequently, it is advised that coastal vegetation spaces in urban ecological systems should be conserved, so as to achieve environmentally viable economies (Olatoye, 2014).

Another major merit of coastal vegetation is that they are centres for conservation and quality control for flora, fauna, water and soil quality (Sandilyan, 2012). Also, Benedict, (2012) postulates that CVEs perform a key role of connecting urban and rural areas with the natural biosphere. Therefore, in order to ensure sustainability and self-sufficiency of urban landscapes, a functional network of CVEs should be a priority to urban planners and ecologists (Braat, 2012). It has also been observed in the literature that the energy costs of cooling buildings in built-up areas can be achieved with the establishment of CVEs (Breuste, 2013). This is because CVEs improve aeration, act as shelterbelts, and ensure evapotranspiration (Olatoye, 2019). Despite the numerous merits of CVEs, these ecosystems are still under threat from urban expansion despite their characteristically fragile nature. Laying credence to this, therefore, the next subsection discusses the threats to CVEs from urban expansion.

6.4 THE STATE OF URBANIZATION AND SUSTAINABILITY OF COASTAL VEGETATION ENVIRONMENTS (CVEs)

CVEs are fragile ecological systems that necessitates continuous conservation and monitoring in order to ensure sustainability (Gardner, 2010). This is because CVEs don't only sustain high biodiversity and productivity (Lefcheck, 2015), they are also storehouses of nutrients and sediments, thereby preventing soil erosion and ensuring soil stabilization (Wall, 2015). Further, Alfaro, (2014) stated that CVEs provide nutritional benefits and means of livelihood for the human populations that live around them. All over the world, loss of coastal vegetal cover is triggered by both anthropogenic and/or naturally occurring factors, urbanization inclusive (Malavasi, 2013; Alfaro, 2014; Gartzia, 2014; Sarah, 2015; Ciccarelli, 2016). In order to meet the demands from increasing populations in urban societies, therefore, a paradoxical phenomenon exemplifying the need for urban development and the necessity for conservation of CVEs thereby arises, and as a result, more urban spaces are required in this regard (Alfaro, 2014). Consequently, this has led to the encroachment on CVEs, so as to meet up with the rising demands of urbanization. Urban expansion has been found to jeopardize these natural CVEs (Neumann, 2015; Feist, 2016), by causing vegetation loss, coastal degradation, erosion, climate change and global warming, just to mention a few (Sustainable Development Solutions Network, 2010; Barbier, 2011). These factors have a colossal impact on CVEs and their surrounding communities thereby resulting in air and environmental pollution (FAO, 2012; Kotsoni, 2017). From the foregoing, this research seeks to bring to the awareness of stakeholders on the uncontrolled threat to CVEs resulting from uncontrolled urban expansion, and hence there is a need to asses, monitor and protect our threatened, fragile and endangered coastal vegetation resources from extinction (Pimm, 2014; Pimm, 2015; Sexton, 2016). From the foregoing, the quest for sustainability in CVE conservation on the one hand and urban development on the other is sine-qua-non to achieving an optimum and highly efficient service delivery in both sectors, hence, this is discussed in section 6.5.

6.5 THE QUEST FOR SUSTAINABILITY OF COASTAL VEGETATION CONSERVATION AND URBAN DEVELOPMENT

Several literature on the management of CVEs advocates for a paradigm that is hinged on sustainability (Porter, 2013; Cumming, 2013). Also, the relevance of ecological system services to human well-being has been over-emphasized in several studies on urban coastal ecology (Jenerette, 2011; Pickett, 2011; Wortley, 2013; Standish, 2013; Albert, 2014). Further, ecologists have emphasized the need for sustainability regarding the conservation and protection of CVEs on one hand, and urban development on the other (Gaston, 2010; Ramalho, 2012; Lee, 2013). While urbanization is viewed by geographers and ecologists from the perspectives of landscape development (Breuste, 2013; Ernstson, 2013; Pacione, 2013; Wu, 2014), environmentalists and ecologists, on the other hand, underscore the need to conserve CVEs in a changing urbanized setting (Standish, 2013), by providing a common platform, which is the landscape – for conservationists, geographers, planners, scientists, and engineers to function together so as to ensure an optimum society where man and nature can both flourish optimally over time. It is on this premise that perceptions were sought from various residents and professionals in BCMM concerning the influence of urban expansion on the conservation of the fragile CVEs in the study area, hence, the analysis of the results are hereby presented.

6.6 ANALYSIS OF FIELD RESULTS

This section presents an analysis of results on the impact of urban expansion on the conservation of CVEs in the study area, as analyzed in subsequent sections. The results on the environmental challeges in the study area are hereby presented in Section 6.6.1.

6.6.1 Environmental Challenges in the Study Area.

The researcher sought to know if there were imminent environmental challenges in BCMM. From the foregoing, question 11 of the questionnaire gave options in the affirmative, or otherwise in this regard, and the responses were analyzed in Table 6.

TABLE 6: ENVIRONMENTAL CHALLENGES IN THE STUDY AREA

Are there environmental challenges in your location?	Frequency	Percentage (%)
Yes	197	80.7
No	33	13.5
Don't Know	14	5.7
Total	**254**	**100**

Table 6 reveals the analysis of the presence or absence of environmental challenges in the study area, based on the respondents' perception. The result depicts that respondents who affirmed the occurrence of environmental challenges were 197 respondents (80.7%). This sends a warning signal to environmental officials, ecology experts and other stakeholders on the need to be more proactive towards ensuring strict compliance with environmental conservation standards. Figures 22 and 23 reveal the effects of urban expnsion resulting into vegetation loss at Quigney and Dimbaza, respectively.

Figure 22: Encroachment of Urban Expansion on Coastal Vegetation at Quigney, BCMM (Source: Author, 2020)

Figure 23: Anthropogenic Disturbances Resulting into Vegetation Loss at Dimbaza, BCMM (Source: Author, 2020)

6.6.2 CAUSES OF COASTAL VEGETATION LOSS IN THE STUDY AREA

The respondents' perception to question 12 relates to the causes of coastal vegetation loss in the study area. The respondents had the choice of ticking multiple options on the questionnaire. The analysis of the responses is tabulated in Table 7.

Table 7: Causes of Coastal Vegetation Loss in the Study Area

(a) Deforestation 169 (66.79%)	(d) Government Policies 106 (41.89%)
(b) Urban expansion 190 (75.1%)	(e) Climate change 128 (50.6%)
(c) Crop Cultivation 120 (47.4%)	(f) Global Warming 133 (52.56%)
Total	**254 (100%)**

Table 7 depicts the perceptions received from the BCMM respondents as causes of coastal vegetation loss in the study area, chief of which is urban expansion, numbering 190 respondents (66.8% of the sampled population), and this assertion is consistent with existing literature such as Ackerly, (2010); and Mantyka-Pringle, (2015) among others. This was followed by deforestation: 169 respondents(66.8%). Also, global warming and climate change, which are caused by human activities in the study area, (e.g. through carbon emissions, deforestation, urbanization, population increase, and so on) accounts for 133 respondents (52.56%) and 128 respondents (50.6%) correspondingly. Furthermore, 106 repondents (41.89%) indicated that the adverse consequences of government policies have exacerbated urban expansion in the study area. This percepion is coherent with BCMM Report, 2017 which stated that as part of the implementation of the SDF and IDP policy framework regarding the provision of more accomodation facilities, over 200,000 units of houses have been constructed in several parts of the study area within the past 20 years. Consequently, this has led to the destruction of CVEs for infrastructural development, and has adversely impacted the BCMM dwellers, as discussed in the next section.

6.6.3: The Impact of Environmental Challenges on BCMM Inhabitants

The next analysis of this chapter is in response to the thirteenth question on the survey form, which revealed findings on the impact of the environmental challenges on BCMM dwellers. The response is graphically expressed on Table 8.

Table 8: Impact of Environmental Challenges on BCMM Respondents

Rating on scale of 1-10	Frequency	Percentage (%)
1(Adversely Poor Impact)	22	9.21
2	27	11.30
3	34	14.23
4	38	15.90
5 (average)	58	24.27
6	21	8.79
7	22	9.21
8	4	1.67
9	3	1.26
10 (Excellently Positive Impact)	10	4.18
TOTAL	**239**	**100**

Table 8 above reveals that 58 respondents (19.7%) rated environmental challenges as “5” (average), while 38 respondents (12.9%) gave a rating of “4”. Also, respondents that gave very poor rating (“1”) were 27 respondents (9.2%). This interprets to mean that quite a sizeable number of respondents are dissatisfied with the environmental impact of the study area.

6.6.4: ANTHROPOGENIC INTERVENTIONS IN THE STUDY AREA.

The researcher sought to know the anthropogenic interventions that occur in the study area. The study reveals the perception of the respondents.

Table 9: Anthropogenic Interventions in the Study Area.

Illegal woodcutting/selective logging 139 (54.7%)	Informal settlements 149 (58.9%)
Conversion of forest land use for crop cultivation 112 (44.1%)	Bush fires 132 (52.0%)
Land development 147 (57.9%)	Illegal waste disposal 136 (53.5%)
Uncontrolled urbanization 198 (78%)	Illegal sand mining 50 (19.7%)
TOTAL	**254 (100%)**

The Table 9 reveals the anthropogenic interventions that occur in the study area, which reveals that 198 respondents (78%) stated uncontrolled urbanization; 149 respondents (58.9%) were of the perception that informal settlements was a major anthropogenic action in the study area, and is evident in locations such as Duncan village, parts of Dimabaza, Mompulelelo and the peripheral areas of East London. This assertion is further buttressed by Kalumba et al. (2018), who stressed the problem of land invasions through unlawful erection of illegal/informal settlements, and shanty structures in west Bank area. Additionally, land development and illegal woodcutting accounts for 147 respondents (57.9%) and 139 respondents (54.7%) respectively, while conversion of ecosystem for agriculture accounts for 112 (44.1%). Also, judging from the responses, it is evident that illegal waste disposal at vegetation land cover areas is still an environmental challenge in the study area, and this poses negative environmental effects , and this include inhibition in the population and activities of soil microbes as well as enzyme activities required for soil fertility, (Gao, 2010; Thavamani, 2012), reduction in the percentage of soil organic matter, (Sebiomo, 2010),decreased soil basal respiration (Chen, 2014). Also, 136 respondents (53.5%) reacted in the affirmative. The researcher's field observation testifies to this perception, and this is illustrated in Figures 24 and 25 which depicts illegal disposal of waste at East London Coast and Umtiza Nature Reserves.

Figure 24: Illegal Dumping of Waste in Vegetation Landuse Site at East London Coast Nature Reserve, BCMM

Figure 25: Illegal Dumping of Waste at Umtiza Nature Reserve in the Buffalo Pass Area, BCMM

As shown in Figures 22 and 23, illegal waste disposal is a major environmental problem in BCMM CVEs, in the following ways: First, it destroys the scenic beauty of CVEs (Sarah, 2015). Secondly, it disrupts soil metabolism and the activities of soil micro-organisms required for soil fertilization (Thavamani, 2012; Wall, 2015). Third, it disturbs soil basal respiration (Dominati, 2010); fourth, waste introduce toxicants through seepage into soils during rainfall and erosion, thereby reducing soil quality and potency (Thavamani, 2012; Osuolale, 2015), and ultimately results in coastal vegetation loss (García-Palacios, 2015). Hence, it is imperative to incorporate waste dumping as an environmental problem in this study.

6.6.5: REASONS FOR ANTHROPOGENIC ACTIVITIES IN THE STUDY AREA

The analysis of question 15 centres on the reasons for the anthropogenic influences of the inhabitants of the study area, which centred on poverty, weak implementation of government policy and ignorance. Figure 26 illustrates the reasons for anthropogenic factors by the respondents. The highest frequency related to the aforementioned is poverty, which is 173 respondents (68.4%). Also, 52 respondents (20.6%) underpinned the weak implementation of government policies (such as the Spatial Development Framework (SDF) and Integrated Development Plan (IDP) policy framework), while 28 respondents (11.1%) claimed it could be due to ignorance.

Generally, it has been noted that land degradation is both a part and consequence of environmental changes leading to loss of valuable land resources (Blaikie, 2015). Therefore, there is a need to strike an equilibrium in the uses to which the land is put in order to minimize the far-reaching ecological effects of coastal vegetation land use change (Wasige, 2013). The ecological problems associated with coastal vegetation land use change are linked with the socio-economic changes of the local population as well as population growth (Lambin, 2010). The findings of this study, therefore, highlight the need for a comprehensive assessment of human activities and the adaptation of sustainable environmental management practices such as close supervision of CVEs in the municipality and making more arable lands available through the restoration of already degraded and impoverished lands (Butt, 2015). The next analysis focuses on environmental challenges to coastal vegetation at BCMM. The result is presented in Figure 26.

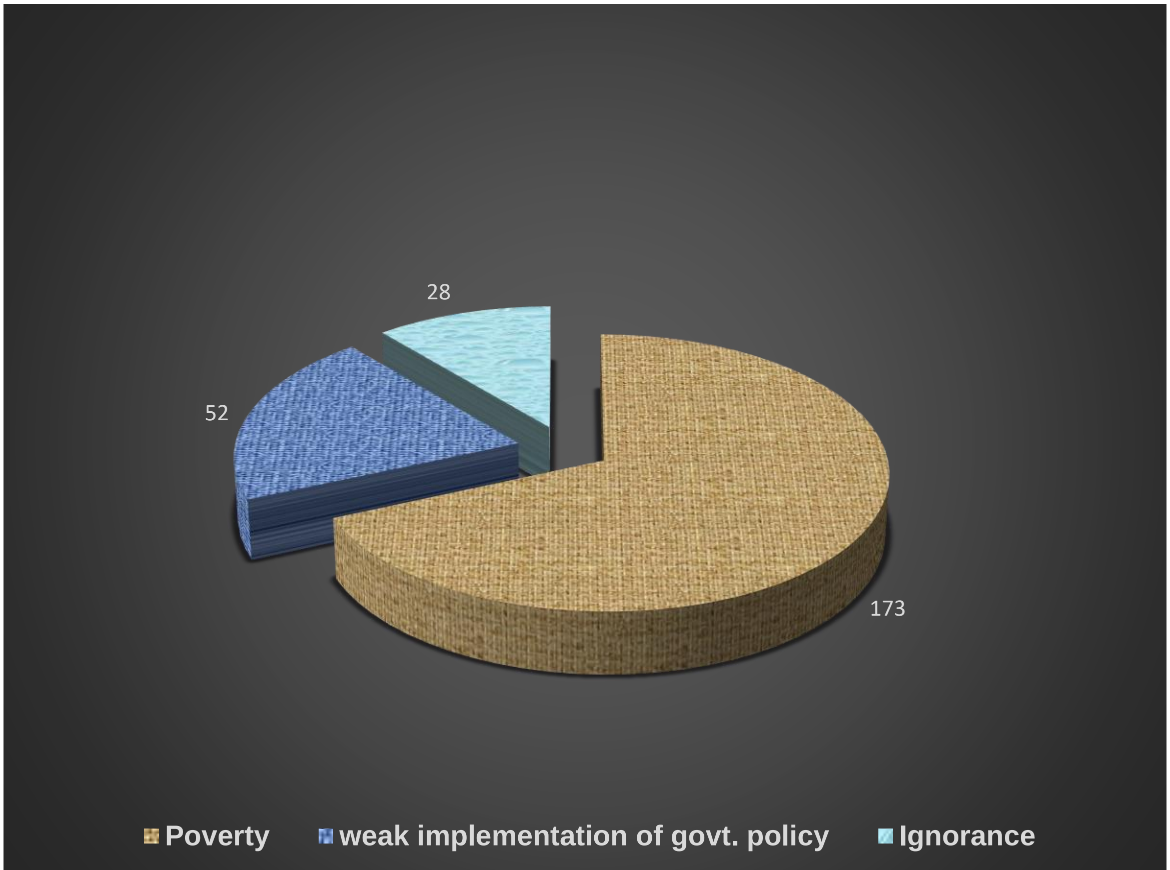

Figure 26: Reasons for Anthropogenic Activities in the Study Area

Figure 26 reveals that 173 respondents stated poverty as a reason for anthropenic activities, while 52 respondents stated weak implementation of government policy as reasons for anthropogenic activities in the study area.

6.6.6 ENVIRONMENTAL CHALLENGES TO COASTAL VEGETATION

This section involves the environmental challenges in the study area. The results are hereby reported. Table 10 depicts the environmental challenges to CVEs at BCMM.

TABLE 10: Environmental Challenges to Coastal Vegetation

Brackish (Salty) Water 171(67.3%)	Steep Slopes 112 (44.1%)
Soil Erosion 127 (50%)	Dusty Winds 194 (76.4%)
Conversion of Costal Vegetation Land to Other Land Uses 192 (75.6%)	

The results in Table 10 above indicate that 112 respondents (44.1%) indicated that there were steep slopes, 192 respondents (75.6%) mentioned conversion of costal vegetation land to other land uses, while 194 respondents (76.4%) attributed dusty winds as environmental challenges to coastal vegetation respectively.

6.6.7: LEVELS OF ADAPTATION TO ENVIRONMENTAL CHALLENGES

The researcher also considered the significance of ascertaining the adaptation of dwellers to environmental challenges in the study area, in response to question 16 of the questionnaire, and is presented in Table 11.

Table 11: Adaptation to Environmental Challenges

Yes - 158 (66.9%)	No - 77 (32.6%)
TOTAL	**235 (100%)**

Table 11 reveals the responses on the adaptation of BCMM inhabitants to environmental challenges, and 158 respondents (66.9%) answered in the affirmative, while 77 respondents (32.6%) stated that they could not adapt to the environmental challenges,such as climate change, soil degradtion, redution in species biodiversity, among others. The subsequent section analyzes the results regarding the reasons for urban expansion.

6.6.8 REASONS FOR URBAN EXPANSION

It is expedient to analyze results regarding the reasons for urban expansion, which is in response to the nineteenth question in the questionnaire, and the results are depicted in Figure 27.

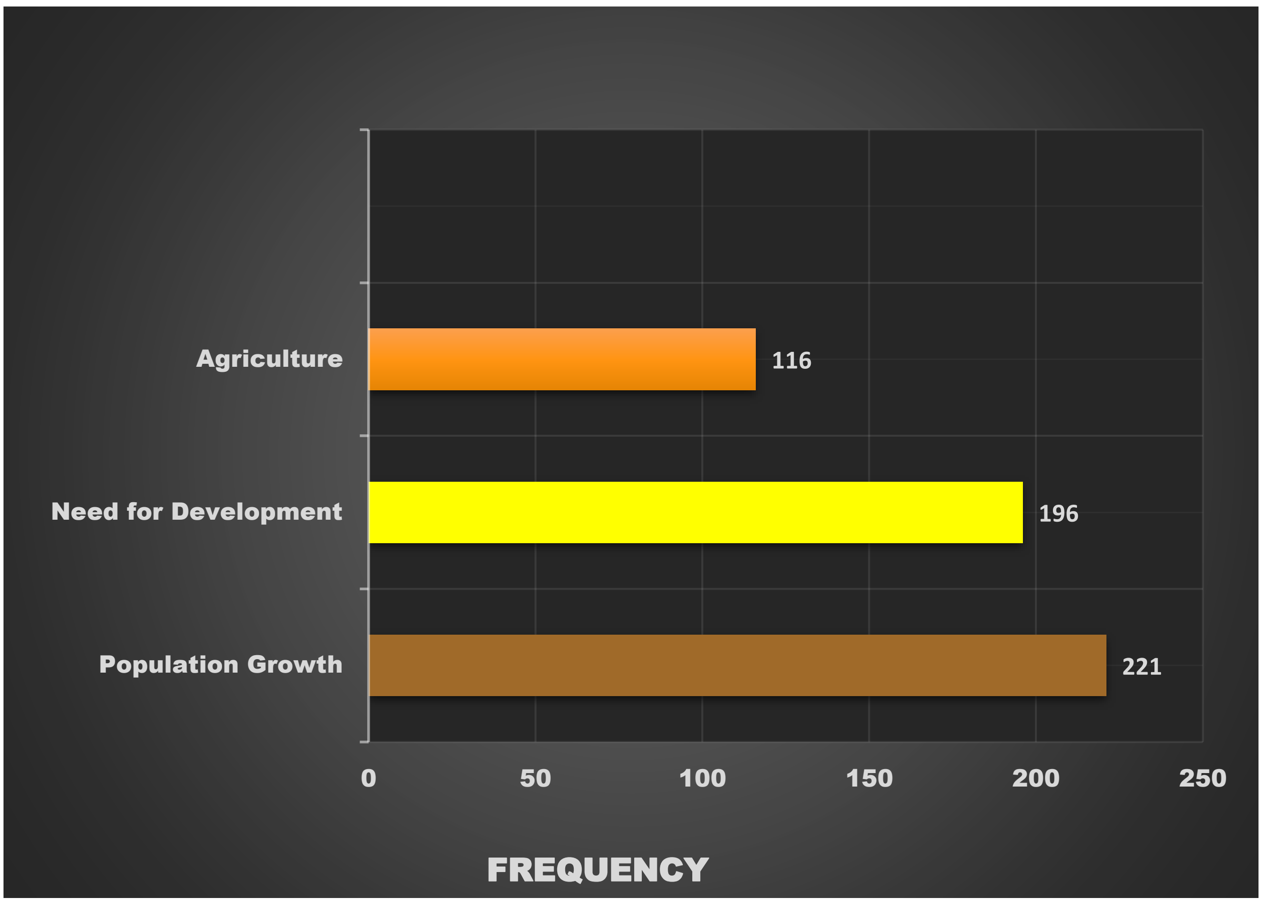

Figure 27: Reasons for Urban Expansion at BCMM

Figure 27 reveals the reasons given by the BCMM respondents for urban expansion in the study area. The result states that 221 respondents (87.4%) identified population growth as a major reason. From the foregoing, Turok, (2012) opined that as population increases, it leads to the provision of basic infrastructure; opening up of new areas for transportation and housing development. This is evident in the construction/extension of the Gonubie Road, Quenera drive, Qumza, Mzamomhle, Amalinda/ New Buffalo river bridge (Ferro, 2013), the development of non-motorized transportation and the special needs transport. Further, urban expansion in BCMM has resulted in the development of Provisional Restructuring Zones (PRZs) in Mdantsane, KWT/Bhisho and East London (Siyongwana, 2017), to curtail urban sprawl, (which is an aftermath of population growth), and upgrade the study area to a metropolitan status. Consequentially, this has led to the opening up of conserved areas to meet this demand. Also, 116 respondents (45.7%) indicated that CVEs in the study area are degraded for other land uses such as crop cultivation and other agricultural purposes, and this assertion is supported in the literature by Bradshaw, (2012) and Hosonuma, (2012).

Urban expansion is a consequence of population increase, which concomitantly results in exploitation of virgin territories (such as coastal ecosystems) to meet higher demands on housing, transportation and other basic urban infrastructure to cater for the teeming population. In the same vein, Edet, (2014) opined that the population has an adverse effect on the preservation of biological diversity. He further stated that the consequences of urban expansion is decline in ecosystem service delivery as well as flora and fauna habitat loss. While healthy ecosystems are highly resilient to impacts of environmental change on account of their capability to sustain ecosystem services on one hand, coastal ecosystems are more vulnerable and cannot provide the required ecosystems regulation and provisioning. It is on this premise, therefore that the East London Nahoon Point Nature Reserve

(NPNR) calls for prompt and proactive attention because urban expansion has resulted in massive depletion of the endangered reserve. Also, the NPNR is an exceptionally significant green asset to BCMM in general, but unfortunately, only a relatively small portion (about 16 hectares) of the reserve presently enjoys conservation status (Cole, 2012).

Figure 28: Depletion of Coastal Vegetation at the Nahoon Point Nature Reserve, East London, BCMM As a Result of Urban Expansion.

6.6.9 IMPACT OF URBAN EXPANSION ON CVEs IN THE STUDY AREA

The impact of urban expansion was assessed at Buffalo City Metropolitan Municipality. In this study, 246 (out of 254) respondents stated their reasons, while the remaining 8 respondents did not provide any answer to the question. The results are presented in Table 12.

TABLE 12: Impact of Urban Expansion on CVEs in the Study Area

Rating on scale of 1-10	Frequency	Percentage (%)
1(Adversely Poor Impact)	66	26.8
2	51	20.7
3	28	11
4	13	5.3
5 (average)	39	15.9
6	23	9.3
7	13	5.3
8	7	2.8
9	6	2.4
10 (Positive Impact)	9	3.7
TOTAL	**246**	**100**

Table 12 presents the analysis based in response to question 21 of the questionnaire, which centres on the impact of urban expansion on the conservation of CVEs in BCMM, which was analyzed on a scale of 1-10 (1=poor impact; to 10= positive impact). The result shows that 66 respondents (26.8%) and 51 respondents (20.7%) rated the impact of urbanization on CVEs as adversely poor and very poor impact correspondingly. Further, 39 respondents (15.9%) gave an average rating. Analysis of the proposed strategies towards the conservation of CVEs is presented in the next section.

6.6.10 PROPOSED STRATEGIES TOWARDS THE CONSERVATION OF CVEs

This study also sought to proffer solutions to uncontrolled urbanization as well as the degradation of CVEs, and control strategies were proposed in this regard. The result is graphically presented.

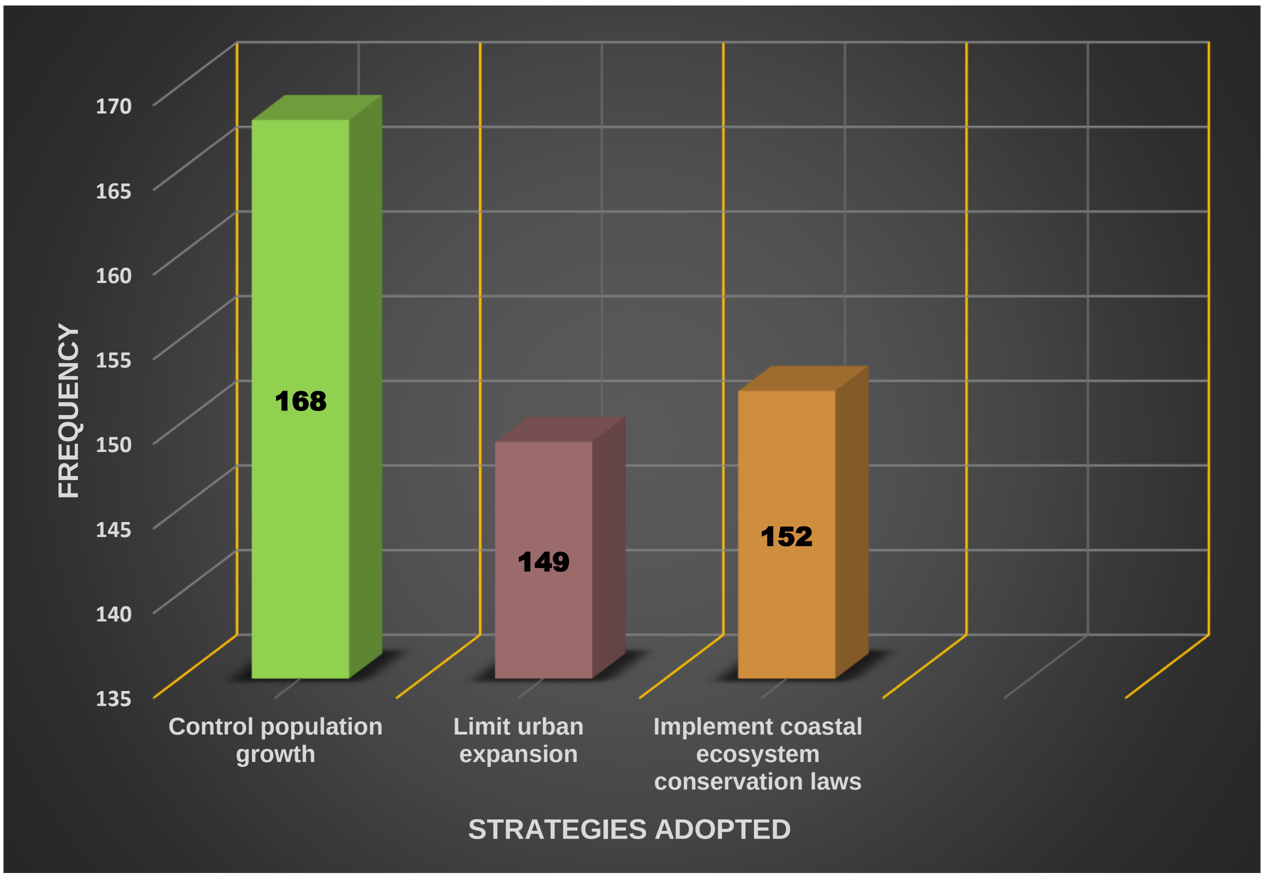

Figure 29: Proposed Strategies Towards the Conservation of CVEs

Figure 29 presents a graphic illustration of the suggested strategies proposed by the respondents for the conservation of CVEs. The greatest frequency of 168 respondents (66.1%) supported population growth control. This assertion is consistent with existing literature such as Estes, (2012); Milner-Gulland, (2012); Crowder, (2014); Nogués-Bravo, (2016); Lardis, (2017) who stated that there is a high correlation between population growth and ecosystem/biodiversity loss. They further opined that controlling human population growth levels will gradually reduce stress on ecosystems. Further, 149 respondents (58.9%) were of the perception that limits should be placed on urban expansion, for the purpose of ensuring sustainability of ecosystem resources, and this confirms the position of ecosystem scholars such as Su, (2011); Su, (2012); Li, (2012); Buhang, (2013); Sadorsky, (2014); Deng, (2015) On a global scale, Buhang, (2013) posited that global urban expansion will continue unabated, even as the world's human urban population is estimated to rise by more than 3 billion people by year 2050, and this will be due to high urban fertility rates and re-categorization of rural territories into urban centres (Buhang, 2013), but a major percentage of future urban expansion will be exacerbated on account of migration from rural communities to the cities, and this will concomitantly result in the development of large slums in the cities, characterized with populations that are largely excluded from accessibility to public services, environmental resources, and employment opportunities (Jiang, 2013; Sadorsky, 2014). The next section analyzes the hypotheses (which relate to knowledge of environmental conservation and urban expansion) that were tested in the course of this research.The next section is focused on the analysis of seven (7) research hypotheses centered on urban expansion and knowledge of coastal environmental conservation.

6.7 ANALYSIS OF RESEARCH HYPOTHESES ON URBAN EXPANSION AND KNOWLEDGE OF ECOLOGICAL CONSERVATION

Logistic regression was operationalized to determine the correlation between knowledge of ecological conservation and urban expansion. The next section analyses the impact of ecological conservation education on anthropogenic interventions based on the data received from the BCMM respondents.

6.7.1 Impact of Ecological Conservation Education on Anthropogenic Interventions Based on Data Received from BCMM Respondents.

This section discusses the research hypotheses on the impact of ecological conservation education on anthropogenic interventions in the study area. The perception of respondents' on coastal vegetation resources is imperative for the overall success of this research due to the following reasons: firstly, on account of severe anthropogenic disturbances occurring in the study area, such as environmental pollution, illegal/selective logging of endangered timber species, conversion of CVE land use for other purposes. Secondly, the advocacy for biodiversity conservation measures by inhabitants would be unrealistic, if the perception of the inhabitants are not assessed. Thirdly, the perception of respondents on CVEs helped to generate the 7 research hypotheses on the impact of ecological conservation education on anthropogenic interventions based on data received from BCMM respondents, and were statistically proved significant.

H_{06}- "The knowledge of ecological conservation is not required by BCMM respondents in the identification of coastal vegetation loss to other land uses".

The test of hypothesis 6 revealed that 80 respondents stated that knowledge of ecological conservation (X variable) is not required by BCMM respondents in the identification of coastal vegetation loss to other land uses (Y variable). Further, the result reveals a p value of 0.223 (which is highly significant), and a Hosmer and Lemeshow's Chi- Square statistics (χ^2) of 12.521, which is interpreted to mean that respondents who are knowledgeable about environmental conservation are 12.521 times more likely to be aware of vegetal loss for agricultural purposes. Therefore the null hypothesis is rejected, and the alternative hypothesis is accepted, which states that *"The knowledge of ecological conservation is required by BCMM respondents in the identification of coastal vegetation loss to other land uses".*

H_{07} - "The encroachment of BCMM dwellers on CVEs for their means of livelihood due to poverty cannot be prevented by their knowledge of ecological conservation".

The test of hypothesis 7 revealed that the encroachment of BCMM dwellers on CVEs for their means of livelihood on account of poverty (Y variable) cannot be prevented by their knowledge of ecological conservation (X variable). Further, the result of hypothesis 7 reveals a p value of 0.246 (which is less than 0.5, and is significant), and Hosmer and Lemeshow's Chi- Square statistics (χ^2) of 15.120, which is interpreted to mean that respondents who are knowledgeable about environmental conservation are 15.120 times more likely not to encroach on CVEs as a result of poverty. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, which states that "*The encroachment of BCMM dwellers on CVEs due to poverty can be prevented by their knowledge of ecological conservation".*

H_{08} – "The knowledge of ecological conservation cannot reduce environmental pollution in the study area"

The test of hypothesis 8 elucidates that knowledge of ecological conservation (X variable) can reduce environmental pollution (Y variable) in BCMM. Further, the result reveals p value of 0.116 (which is significant), Odds Ratio (OR= 0.472), at 95% significance Confidence Interval (CI) of between 0.210 and 1.063, as well as Hosmer and Lemeshow's Chi- Square statistics (χ^2) of 3.393, which is interpreted to mean that respondents who are informed about the conservation of the environment are 3.393 times more likely to reduce environmental pollution than those who are not. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, which states that *"The knowledge of ecological conservation reduces environmental pollution in the study area".*

H_{09} – "The knowledge of ecological conservation cannot ameliorate ecosystem biodiversity loss in the study area".

In the course of examining hypothesis 9, 109 respondents stated that the knowledge of ecological conservation (X variable) can help to ameliorate ecosystem biodiversity loss (Y variable), in the study area, while 44(17.4%) opined differently. Further, the result reveals a p value of 0.348 (which is significant), Odds Ratio (OR= 0.227), at 95% significance Confidence Interval (CI) of between -0.389 and 0.133, as well as

Hosmer and Lemeshow's Chi- Square statistics (χ^2) of 30.700, which is interpreted to mean that respondents who are acquainted about environmental conservation are 30.700 times more likely to ameliorate ecosystem biodiversity loss in their communities than those who are not. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, which states that *"The knowledge of ecological conservation ameliorates ecosystem biodiversity loss in the study area".*

H_{010} – "Adaptation to climate change effects in the study area cannot be harnessed by knowledge of ecological conservation".

The logistic regression analysis for hypothesis 10 reveals that 119 respondents opined that adaptation to climate change effects (Y variable) in the study area can be harnessed by knowledge of ecological conservation (X variable). Further, the result reveals a p-value of 0.196 (which is significant), Odds Ratio value (OR= 0.402), at 95% significance Confidence Interval (CI) of between 0.225 and 0.719, as well as Hosmer and Lemeshow's Chi- Square statistics (χ^2) of 9.751, which is interpreted to mean that respondents who are conversant with environmental conservation are 9.751 times more likely to adapt to the effects of climate change in their communities than those who are not. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, which states that *"Adaptation to climate change effects in the study area can be harnessed by knowledge of ecological conservation".*

H_{011} – "Uncontrolled urban expansion is not prevented by knowledge of ecological conservation".

The binary logistic regression analysis for hypothesis 11 reveals that 108(42.7%) respondents opined that ecological conservation knowledge (X variable) promotes the control of urban expansion (Y variable) in the study area, while 47(18.6%) gave other reasons. Further, the result reveals a p value of 0.314 (which is significant), Odds Ratio value (OR= 0.264), at 95% significance Confidence Interval (CI) of between 0.155 and 0.450, as well as Hosmer and Lemeshow's Chi- Square statistics (χ^2) of 25.008, which is interpreted to mean that respondents who are conversant with ecological conservation are 25.008 times more likely to support the control of urban expansion in BCMM than those who are not. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, which states that *"Uncontrolled urban expansion is prevented by knowledge of ecological conservation".*

H_{012} – "Adherence to ecological conservation laws is not encouraged by knowledge of ecological conservation".

The test for hypothesis 12 states that adherence to ecological conservation laws (X variable) is not encouraged by ecological conservation knowledge (Y variable), and the result revealed that 99(39.1%) respondents posited that the knowledge of environmental conservation encourages the implementation of environmental conservation laws, while 52(20.6%) opined differently. Further, the result reveals a p-value of 0.203 (which is significant), Odds Ratio value (OR= 0.431), at 95% significance Confidence Interval (CI) of between 0.258 and 0.722, as well as Hosmer and Lemeshow's Chi- Square statistics (χ^2) of 10.421, which is deduced to mean that respondents who are well-informed about ecological conservation are 10.421 times more likely to adhere to environmental laws in the study area than those who are not. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, which states that *"Adherence to ecological conservation laws is greatly encouraged by knowledge of ecological conservation".* All the hypotheses analyzed support the research outcome of other analysis relating to urban expansion and ecological conservation, as elucidated in chapters 5, 6 and 7 respectively. The results of the hypotheses are presented in Table 13.

Table 13: Impact of Ecological Conservation Education on Anthropogenic Interventions at BCMM CVEs

Variables	**Yes**	**No**	**Test statistics and p-value**
Gender			OR = 0.914;95%CI (0.554, 1.508) χ^2=0.123; P= 0.022** df = 1
Male	71(28.2%)	50(19.8)	
Female	74(29.4%)	57(22.6%)	
Does knowledge of ecological conservation prevent the removal of vegetal resources in the study area on account of poverty?	113(65.3%)	60(34.7%)	OR=0.339; 95%CI (-1.637,0.527) χ^2=15.120; P= 0.246** df = 1
Has knowledge of ecological conservation influenced population growth in the study area?	134(53.2%)	86(34.1%)	OR.= 0.292; 95%CI (0.132, 0.646) χ^2=1.188 P= 0.2** df = 1
Has knowledge of ecological conservation influenced the need for urban development in the study area?	126(49.8%)	69(27.3%)	OR.= 0.267; 95%CI (0.143, 0.497) χ^2=18.544; P= 0.271** df = 1

Has knowledge of ecological conservation affected environmental pollution levels in the study area?	134(53.0%)	92(36.4%)	OR= 0.472; 95%CI (0.210, 1.063) χ^2=3.393; P= 0.116** df = 1
Has knowledge of ecological conservation influenced environmental degradation levels in the study area?	112(44.3%)	52(20.6%)	OR= 0.274; 95%CI (0.159, -0.301) χ^2=22.975; P= 0.301** df = 1
Has knowledge of ecological conservation influenced ecosystem biodiversity loss in the study area?	109(43.1%)	44(17.4%)	OR= 0.227; 95%CI (0.133, -0.389) χ^2=30.700; P= 0.348** df = 1
In your knowledge of vegetal resources, do you view dense vegetation areas as wastelands for urban development?	114(46.2%)	77(31.2%)	OR= 0.629; 95%CI (0.346, 1.144) χ^2=2.326; P= 0.097** df = 1
Does your knowledge of ecological conservation	135(54.4%)	89(35.9%)	OR= 0.469; 95%CI (0.209, 1.112)

enhance the ecosystem diversity in the study area?			χ^2=10.707; P= 0.208^{**} df = 1
Does knowledge of ecological conservation promote urban sustainability	101(39.9%)	47(18.6%)	OR= 0.336; 95%CI (0.200, 0.564) χ^2=17.417; P= 0.262^{**} df = 1
In your understanding of biodiversity conservation, should urban expansion be controlled?	108(42.7%)	47(18.6%)	OR= 0.264; 95%CI (0.155, 0.450) χ^2=25.008; P= 0.314^{**} df = 1
In your perception of ecological conservation, should conservation laws be implemented?	99(39.1%)	52(20.6%)	OR= 0.431 95%CI (0.258, 0.722) χ^2=10.421; P= 0.203^{**} df = 1

6.8 CONCLUSION

Urban expansion is the consequence of socioeconomic development, and it is manifested through the physical development of urban environments. The rapid growth in urbanization results in multifaceted landscape changes, which further culminates in the altering of environmental systems, as well as CVEs structure and functioning, no wonder that CVEs have been imperiled by severe stresses from human interventions, such as urbanization, construction of roads airport project and opening of virgin areas as socio-economic centres of development in various parts of the metropolis. Consequently, urban expansion in the study area has led to an uncontrolled threat to the coastal ecosystem culminating into the extinction of endemic species of flora and fauna, loss of habitat for wildlife, disruption of microbial activities and soil metabolism required for vegetal growth, change in the micro-climatic conditions of the study area, soil erosion, environmental pollution through illegal dumping of solid waste, loss of vegetation LULC to other land use types among others. From the foregoing, this research seeks to bring to the awareness of stakeholders on the uncontrolled threat to CVEs resulting from urban expansion, and hence there is need to asses, monitor and protect our threatened, fragile and endangered coastal vegetation resources from extinction. Also, significant environmental changes such as global warming and climate change is witnessed in the study area. It is therefore imperative at this juncture to advocate for the control of urban expansion in its totality, and in addition, it is germane for urban planners to ensure that sustainable urban development policies are entrenched in constitutions at local, regional and national scales. It is also evident that future cities will depict our decisions, values and interests, and ultimately, our actions on the ecosystem, and these will consequentially determine the fate of the human, flora and fauna species. Therefore, urban expansion has to embrace the sustainability of ecological systems in scientific practice and as its ultimate goal. It is on this premise that this chapter sought to address the anomalies associated with urban expansion, coastal vegetation environments (CVEs) and sustainability paradox in BCMM, which is the third study objective of this research. This chapter discussed the concept of urbanization, urban sustainability, merits of conserving CVEs and threats to CVEs from urban expansion. Other sub-topics that were discussed in this chapter include:

The state of urbanization and sustainability of CVEs, as well as the quest for sustainability regarding coastal vegetation and urban development. In addition, central sub-topics in relation to the overarching objective of this chapter were statistically analyzed, based on the following sub-headings: the environmental challenges of BCMM, causes of coastal vegetation loss, the impact of environmental challenges on BCMM inhabitants, anthropogenic activities and adaptation measures undertaken in the study area, as well as the reasons for, and impacts of urban expansion in the study area. This research results in this chapter conforms with results derived in Chapters four, five, and seven respectively. The next chapter discusses the geo-spatial mapping and time series change detection analysis of the coastal vegetation of BCMM using Geographic Information Systems and Remote Sensing Technologies.

CHAPTER SEVEN

GEOSPATIAL ANALYSIS OF LANDUSE LANDCOVER CHANGE (LULCC) DETECTION OF COASTAL VEGETATION LOSS AT BCMM FROM 1998-2018

7.1 INTRODUCTION

This chapter is focused on investigating the coastal vegetation landuse landcover change (LULLC) detection at BCMM, South Africa using Geographic Information Systems and remote sensing technologies. The study was carried out with the acquisition of satellite data on the LULC of BCMM. It is also imperative to state that this study contributes to science by bringing to the fore the growing complexity of land cover challenges as well as environmental sustainability problems (such as environmental degradation) characterized by coastal urbanization and the intricacies of vegetation conservation. By means of definition, land refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, and/or artificial structures, and examples of land cover classes include : grassland, deciduous forest and bare soil, water and snow. Land cover of the earth's land surface has been changing since time immemorial and is likely to continue to change in the future (Olatoye, 2019). Land cover is important for global monitoring studies, resource management, and planning activities. Understanding the distribution and dynamics of land cover is crucial to the better understanding of the earth's fundamental characteristics and processes, including productivity of the land, the diversity of plant and animal species, and the biogeochemical and hydrological cycles (Ejaro, 2013). Assessing and monitoring the distribution and dynamics of the world's forests, shrublands, grasslands, croplands, barren lands, urban lands, and water resources are important priorities in studies on global environmental change as well as in daily planning and management. Information on land cover and landcover change is needed to manage natural resources and monitor the global environmental changes and their consequences (Giri, 2012).

Land-cover change can be characterized as land-cover conversion and modification (Kavzoglu, 2016). Landcover conversion is a change from one land-cover category to another, and modification is a change in condition within a land-cover category (Clerici, 2014). An example of the former is changed from cropland to urban land, and an example of the latter is the degradation of forests. Vegetation degradation may be due to change in phenology, biomass, vegetation density, canopy closure, insect infestation, and storm damage. Conversion is generally easier to measure and monitor than modification using remotely sensed data (Deng, 2010). Modification is usually a long-term process and may require multiyear and multiseasonal data for accurate remote sensing of land use and land cover land-use change is a change in the use or management of land by humans (Zhu, 2016). Land-use change may change without land-cover conversion or modification. Both natural and anthropogenic forces are responsible for the change. Natural forces such as continental drift, glaciation, fooding, and tsunamis and anthropogenic forces such as conversion of forest to agriculture, urban sprawl, and forest plantations have changed the dynamics of LULC types throughout the world. In recent decades, anthropogenic land-use/land-cover change (LULLC) has been proceeding much faster than natural change (Olatoye, 2020). This unprecedented rate of change has become a major environmental concern worldwide. As a result, almost all ecosystems of the world have been altered by humans, thereby undermining the capacity of the planet's ecosystems to provide goods and services. Two main forces responsible for anthropogenic changes are technological development and the burgeoning human population (Kavzoglu, 2016).

7.2 MAIN PURPOSE OF THE CHAPTER

The main purpose of this chapter underscores the importance that Landuse Landcover (LULC) plays on the global carbon cycle, both as a source and a sink at BCMM (Mahmood, 2014), and in the exchange of greenhouse gases between the land surface and the atmosphere. However, urban expansion has led to vegetation loss, environmental degradation, higher concentrations of carbon dioxide into the atmosphere, changes land-surface albedo, evapotranspiration and urban heat island effects , and these are major effects recorded in the study area (Chen, 2015). Addditionally, there is very scarce information available on LULLC detection of the entire study area in literature. Hence, it is on this premise that this study considered the importance of assessing the LULLC detection analysis of the study area, with a view to providing scientific explanation on urban coastal vegetation loss attributed to urban expansion. Thus, this research serves as a viable working document for town planners, ecologists, policy makers and other stakeholders as regards the need for controlled urban expansion and conservation of the municipality's fragile CVEs. In light of this, the theoretical framework, the UGS Theory was adopted for this study on account of its support for vegetal resources conservation, which the theory promotes. Further, the research findings in this chapter helped to harmonize the principles of the UGS Theory with scholarly arguments in literature as well as providing scientific contributions to the actualization of the overarching aim of this study. It is also germane to stress that the analysis of research findings conforms with the overarching aim of the study, as expounded in the sections on research findings. It is on this premise that the next section discusses the Landsat imageries and which was utilized in assessing land cover changes for this study.

7.3 LANDSAT THEMATIC IMAGERIES

According to Vittek, (2014); Zhu, (2016), Landsat satellites collect data on phenomena on the earth's surface, as they are known to revolve in the polar orbit and their functionlity is programmed with the rotation of the earth (Sarkhosh, 2012). The satelite collects data by using passive sensors onboard the satellite that detect radiation emitted from the earth in different bands. The characteristics of Landsat satelites are depicted in Table 14.

Table 14: Characteristics of Landsat Satelites

Name of satelite	Location above the earth	Spatial resolution	Spectral resolution	Temporal Resolution	Special Capabilities of Landsat
LANDSAT	705 km	30 metres	6 to 9 bands	16 days	Special capabilities in LULC monitoring, change detection, urbanization, climate change, carbon sequestration, wildfire, drought and a host of other studies centred on natural or anthropogenic causes.

Table 14 depicts the characteristics of landsat satelites. The table reveals that Landsat satellite orbits at 705 kilometers (about 438 miles above the earth), at 98.2^0 inclination, circumnavigates the earth every 99 minutes, with a 16-day temporal resolution, crossing the equator at 15 minutes earlier or later than 9.45am (Seong, 2015). The Landsat Thematic Mapper (TM) comprises of six spectral bands with a spatial resolution of 30 meters, with Band 6 as a thermal band. Landsat satellites have special capabilities in LULC monitoring, change detection, urbanization, climate change, carbon sequestration, wildfire, drought and a host of other studies centred on natural or anthropogenic causes. According to Potatov, (2012), Landsat satellites are passive sensors because they do not produce their own radiation, but obtain insulation from the sun as well as thermal radiation from the surface of the earth.

7.4 ANNOTATED BIBLIOGRAPHY ON LULC CHANGE STUDIES

Several scholars have conducted studies on LULC change detection. An annotated bibliography on LULC change studies is depicted in Table 15.

Table 15: Annotated Bibliography on LULC Change Studies

S/N	Author	Research Topic	Interval of change detection studied	Results from land cover change detection
1.	Deng, (2010)	Spatio-Temporal dynamics and evolution of land use change and landscape pattern in response to rapid urbanization	1996-2006 (10 years)	The results indicated that the rapid urbanization process has brought about enormous land use changes (composing of altogether 79.83% of the total change) and urban growth at an unprecedented scale and rate and, consequently, given rise to substantial impacts on the landscape pattern.
2.	Zhao, (2010)	Using thematic mapper data for change detection and sustainable land use of cultivated land: Case of Yellow River Delta, can	1987-1998 (11 years)	The study utilized multi-temporal composite and classification, and image rationing when remote sensing data acquired in the suitable season are available, and distinct spectral characteristics of different land use types exist. The results showed that the area of cultivated land in this region decreased by 5321.8 ha over the period 1987 to 1998, 483.8 ha every year, mainly concentrated in the central paddy field region and northeast dry land region.
3.	Mendoza-González (2012)	Landuse change and its effects on the value of ecosystem sercices along the coast of the Gulf of Mexico	1995-2006 (11 years)	The results indicated that from 1995–2006, urban sprawl was predominant, and occurred over mangroves, grasslands, croplands and the beach. There was a net loss ($US 2006/ha/year) of $\$1.4 \times 10^3$ in Boca del Río, $\$7 \times 10^5$ in Chachalacas and $\$1 \times 10^5$ in Costa Esmeralda. However, after losing ecosystem services such as coastal protection or scenic value and recreation, the apparent gains from urban development are lost.
4.	Beuchle, (2015)	Landcover changes in the Brazillian Cerrado and the Caatinga biomes	1990-2010 (10 years)	By 2010, the percentage of natural vegetation cover remaining in the Cerrado was 47% and in the Caatinga 63%. The annual (net) rate of

		based on remote sensing approach		natural vegetation cover loss in the Cerrado slowed down from −0.79% yr^{-1} to −0.44% yr^{-1} from the 1990s to the 2000s, while in the Caatinga for the same periods the rate increased from −0.19% yr^{-1} to −0.44% yr^{-1}. In summary, these Brazilian biomes experienced both loss and gains of Tree Cover and Other Wooded Land; however a continued net loss of natural vegetation was observed for both biomes between 1990 and 2010 to urbanization.
5.	Rawat, (2015)	Monitoring land use and land cover changes using remote sensing and GIS techniques. A case of Hawalbagh block, Uttarakhand, India.	1990-2010 (20 years)	The images of the study area were categorized into five different classes namely vegetation, agriculture, barren, built-up and water body. The results indicate that during the last two decades, vegetation and built-up land have been increased by 3.51% (9.39 km^2) and 3.55% (9.48 km^2) while agriculture, barren land and water body have decreased by 1.52% (4.06 km^2), 5.46% (14.59 km^2) and 0.08% (0.22 km^2), respectively. The study highlights the importance of digital change detection techniques for nature and location of change of the Hawalbagh block.
6.	Butt, (2015)	Land use change mapping using remote sensing and GIS. A case of Simly watershed, Islamabad, Pakistan	1992-2012 (20 years)	Landsat 5 and SPOT 5 were utilized for the years 1992 and 2012 respectively. The watershed was classified into five major land cover/use classes: Agriculture, Bare soil/rocks, Settlements, Vegetation and Water. Resultant land cover/land use and overlay maps generated in ArcGIS 10 indicated a significant shift from vegetation and water cover to agriculture, bare soil/rock and settlements cover, which shrank by 38.2% and 74.3% respectively. These land cover/use transformations posed a serious threat to watershed resources. Hence, proper management of the watershed is required or else these resources will soon be lost and no longer be able to play their role in socio-economic development of the area.

7.	Jana, (2016)	Seasonal change monitoring and mapping of coastal vegetation types along Midnapur-Balasore coast, Bengal, using multi-temporal landsat data	2000-2015 (15 years)	The results indicated that from pre-monsoon 2000 to post-monsoon 2002, the net change of coastal vegetation was negative, which was quantified as 61.83 ha, due to high anthropogenic pressure, commercial aquaculture, highly eroding nature of the coast and tidal activities. The NDVI derived from ETM+ images provide useful information to monitor coastal vegetation changes, especially the natural plants growing on sand dunes, mangroves and salt marsh vegetations. The analysis of NDVI variations showed the qualitative information about the vegetation. On the other hand classified image provide quantitative information about the coastal vegetation.
8.	Zhu, (2016)	Including land cover changes in analysis of greeness trends using all available Landsat 5.7 and 8 images: A case study from Guangzhou, China	2000-2014 (14 years)	The study assessed the consistency of surface reflectance from Landsat 5, 7 and 8. In the analysis of greenness trends for Guangzhou. In spite of massive amounts of development in Guangzhou from 2000 to 2014, greenness increased, mostly because of gradual change. Overall, this analysis demonstrates the importance of considering land cover change when analyzing trends in greenness from satellite time series in areas where land cover change is common.
9.	Kalumba, (2018)	Assessing industrial development influence on land use/cover drivers and change detection in West Bank, East London, South Africa	1998-2013 (15 years)	The study revealed that 22.4% of the vegetation in the study area was converted into built-up, 32.7% of water areas were colonised by vegetation, and close to half (42.12% and 41.6%) of the bare land and built-up changed to vegetation respectively. For the period, 2007 – 2013, less than a quarter (10.1%) of the vegetation was transformed into built-up, while more than one-third (33.6%) of the built-up, 14.3% of water and more than half the bare land were converted into vegetation. The rest of the changes were very minimal and varied across classes.

The remotely-sensed imageries utilized in this research include three Landsat images, acquired within the winter months (most especially July) due to clear clouds and less windspeed in order to guard against atmospheric distortion and radial imbalance. This conforms with Rawat (2015), Zhu, (2016), among others, who performed change detection within 20 years interval (or less). These time-series images were acquired during the summer seasons on account of clear atmospheric conditions devoid of cloud cover, and were freely downloaded from the Landsat collections of the USGS (http://glovis.usgs.gov) explorer website. The study area was selected to account for the land-use changes that have occurred in BCMM (such as urban expansion) since the post-apartheid period of 1994.

LULC are two distinct expressions frequently used interchangeably in the course of this chapter. Land cover is defined as the physical phenomena on the surface of the earth such as vegetation, soil, water and built-up areas (Vittek, 2014). Further, LULC information and their optimum utilization is indispensable for the selection, development and execution of land use structures to cater for increasing demands by the locales (Acheampong, 2015). LULC records also fosters land use dynamism emanating from changing demands of population expansion. In spite of the fact that LULC changes do not necessarily denote land degradation, nevertheless, natural and anthropogenic factors, which are motivated by an array of social origins (Stefanidis, 2013). Consequently LULC changes lead to distress biodiversity and other processes that ultimately culminate in biospheric and climatic challenges (Zaehle, 2014). The next section discusses the research findings for the chapter.

7.5 RESEARCH FINDINGS

7.5.1 **The Composite Band Classification of the Study Area**

The composite bands for the study area were done using composite bands 4- 3- 2 derived from Landsat 5 thematic mapper imageries for 1998 and 2008, while Landsat 8 was used for 2018 imagery . Landsat imageries were utilized for this study due to its special capabilities in LULC monitoring and change detection. The composite bands clssification results are depicted in Figure 30.

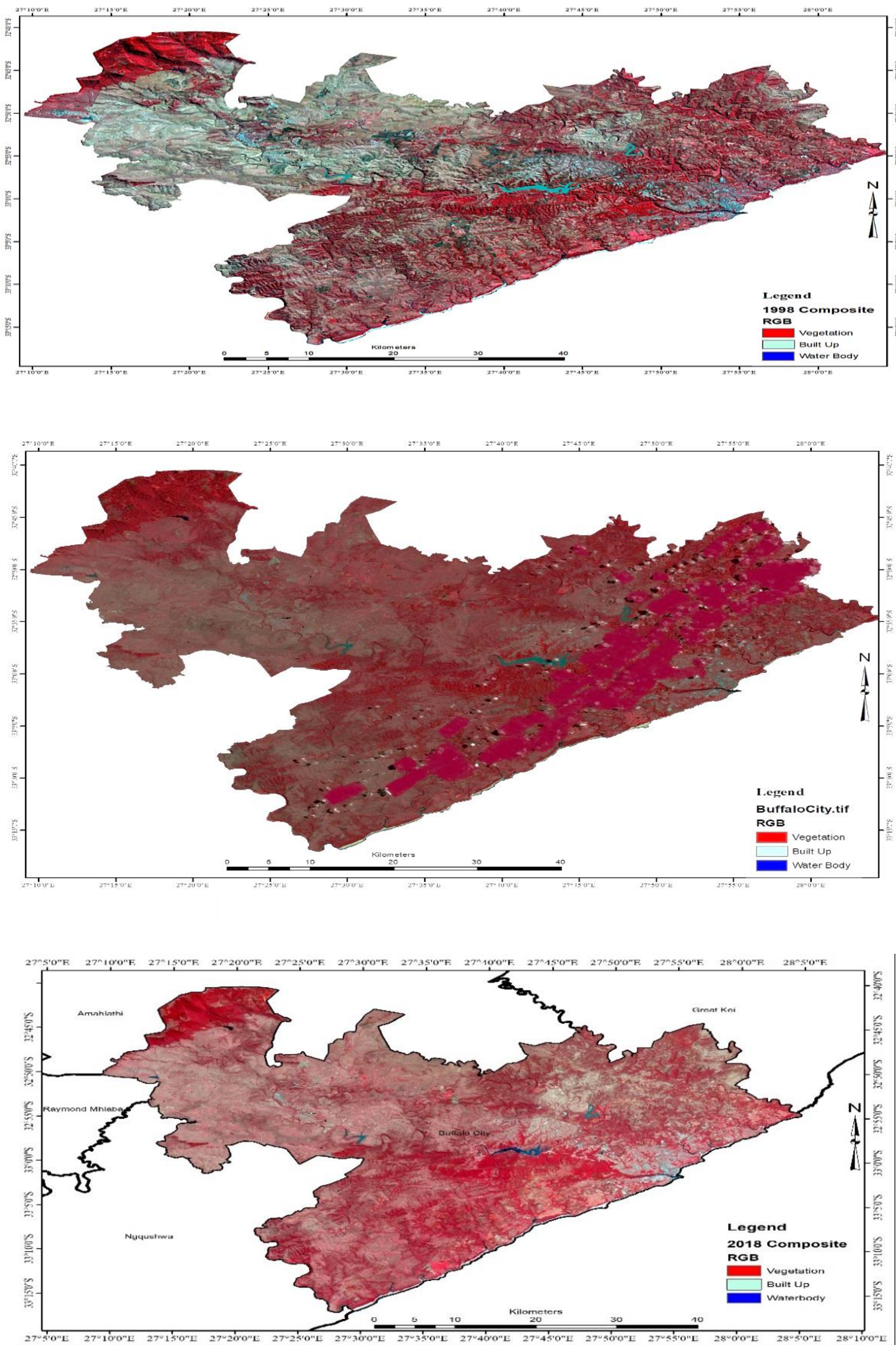

Figure 30: False Colour Composite Band Images of the Study Area (1998-2018)

Figure 30 reveals the false colour composite bands of 4 (Red), 3 (Grey) and 2 (Blue) of the study area. The light and dark red colours represent the forest and grassland vegetation respectively, while grey and blue colours depict built-up areas and water bodies respectively. The Figure reveals increasing urbanization in 2018, as well as decreasing vegetation in 2018 respectively.

7.6 Description of Land Cover Classes and Results

The study area was classified into five (5) classes namely: Bare ground, water bodies, grassland, forest vegetation, and built-up areas. This classification conforms with emirical studies of other scholars such as Deng, (2010); Varshney, (2013); Rawat, (2015) and Thenkabail, (2016). The description of land cover classification is further described in Table 16.

TABLE 16: DESCRIPTION OF LAND COVER CLASSES

S/N	Classes	Description of Land Cover Classes
1.	**Bare Ground**	Areas of bare rock, sand, silt, gravel or other earthen material with little or no vegetation including beaches and sandy areas. Other examples include areas of bedrock, desert pavement, scarps, talus slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material.
2.	**Water Bodies**	Areas of open water, generally with less than 25% cover of vegetation or soil. All types of water such as sea and lakes.
3.	**Forest Vegetation**	Areas dominated by trees generally greater than 5 meters tall, and greater than 10% of total cover. More than 75% of tree species maintain their leaves all year. Canopy is never without green foliage. They are commonly found around steep slopes and less populated areas. Canopy cover of 50–80%. Total canopy cover around 90%, typically a mix of trees (60%), shrubs (20%), grasses (10%) and unproductive land (10%).
4.	**Grassland**	Land cover dominated by shrubs and crops that are less than 5 meters in height. These areas are also subject to intensive management such as tilling, and can be utilized for grazing. These areas also account for more than 70% of the land, and are frequently observed on level lands (plains, plateaus, foot slopes and valley floors).

5.	**Built-Up Areas**	Areas characterised by a density of human structures such as houses, commercial buildings, asphalt, concrete, and artificial surfaces. They include areas of residences, administrative buildings, industrial and trade enterprises.

7.7 MAXIMUM LIKELIHOOD CLASSIFICATION (MLC)

The MLC results for the study area in the year 1998 to 2018 is depicted in Table 17.

Table 17: Spatial Distribution of BCMM LULC in 1998, 2008 and 2018

S/N	Feature	Area (km^2) 1998	Area (km^2) 2008	Area (km^2) 2018
1.	Bare Ground	1110.346	56.239836	536.348176
2.	Water Bodies	33.81448	32.14646	22.797197
3.	Forest	804.9369	839.5664	338.012174
4.	Grassland	605.205	1002.948	1735.99065
5.	Built-up Areas	193.8586	817.2702	115.03479
	TOTAL	**2748.161**	**2748.161**	**2748.161**

Table 17 depicts the spatial distribution of LULC in the study area from year 1998-2018 respectively. From the foregoing, 5 classifications were produced from the LULC image namely bare ground, forest, grassland, water bodies and built-up areas. In the period under review, grassland recorded an areal extent of 605.205 km^2 in 1998 occupying 22% of the study area. The aerial coverage of grassland vegetation increased from 605.205 km^2 to 1735.9 km^2 (from 1998 to 2018 respectively), amounting to about 41% increase. Also, forest cover had diminished in aerial extent from 804.9km^2 in 1998 to 338km^2, which is approximately 17% loss. This loss is due to increasing urbanization that took place in the study area within these years, which resulted in vegetation loss. Also, water bodies in the study area witnessed an decrease from 33.8km^2 in 1998 to 22.7 km^2 in 2018. The results derived from image classification and interpretation, in combination with field authentication, specified that intensive spatial development initiatives have been executed in BCMM during the period under review. Spatio-temporal interventions that have been expedited within the study area include land reclamation and urban expansion through the construction of housing, roads and airport projects, and opening of virgin areas as socio-economic centres of development in various parts of the metropolis (as discussed in chapter 4).The MLC images of the study area from 1998 to 2018 are depicted in the Figure 31.

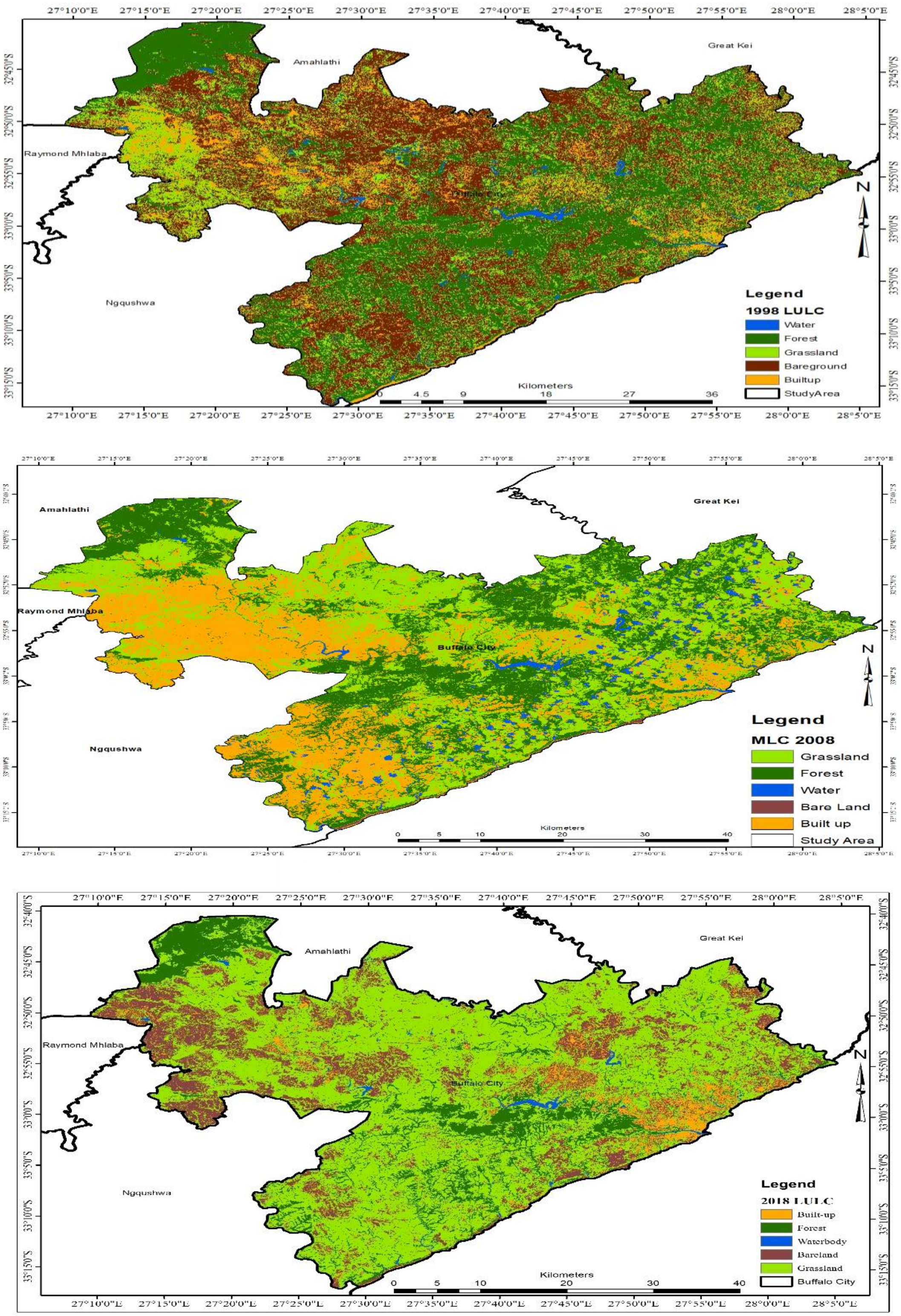

Figure 31: Maximum Likelihood Classification (MLC) of Study Area

The degree of LULC change in the study area is further presented in Figures 32 and 33.

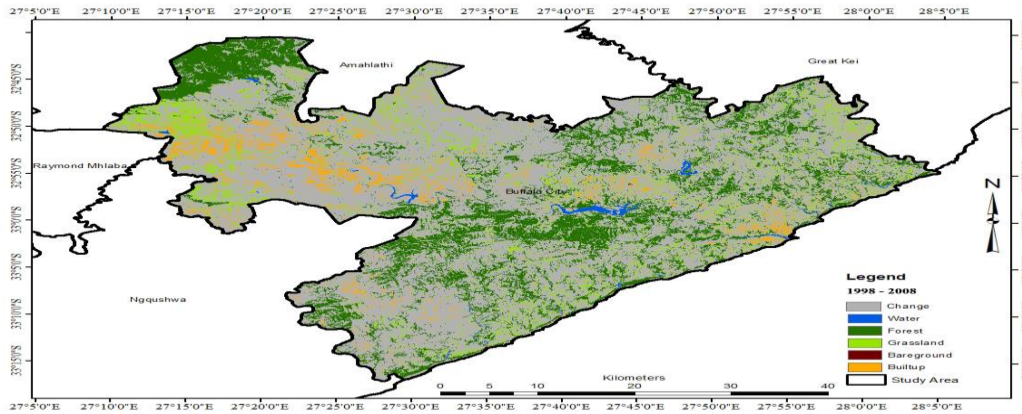

Figure 32: LULC Change Detection Image of Study Area from 1998-2008

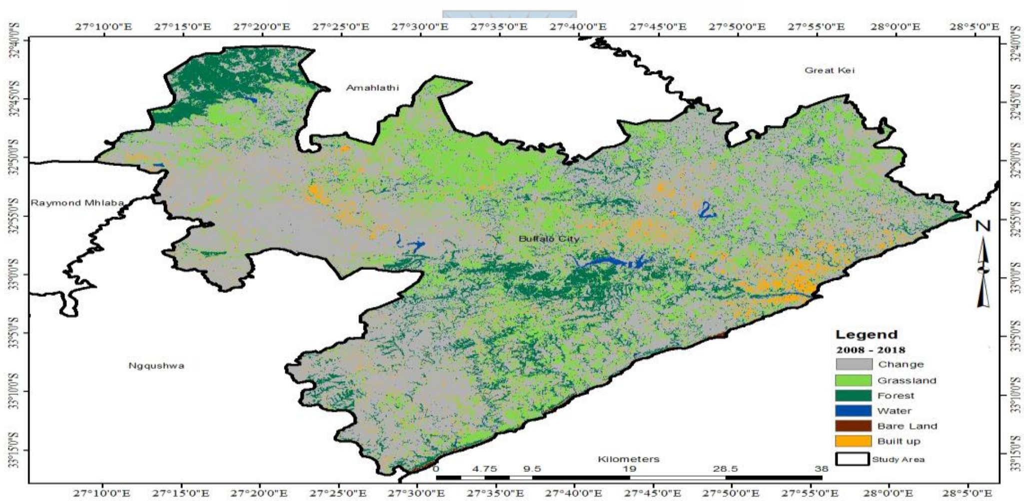

Figure 33: LULC Change Detection Image of Study Area from 2008-2018

Figures 32 and 33 depict the spatio-temporal changes within the BCMM ecological space, thereby reflecting the dynamics of human interference on the metropolis. The visual interpretation was expedient in categorizing the locations and degrees of change in grassland, forest vegetation, urban areas and water bodies. The rate of change depicts increases in urban expansion and grassland, as well as decreased vegetation LULC and water bodies from 1998 to 2018.

7.8 CHANGE DETECTION ALGORITHMS CARRIED OUT ON STUDY AREA

Change detection algorithms were expedited in this study so as to disclose the exactness betweeen an accurate standard expected and a classified image of unidentified quality. Hence, change detection algorithms were carried out to further validate LULC classification results. From the foregoing, three different change detection algorithms were applied to the three imageries of the study area (1998, 2008 and 2018), and these were conducted after the processing stage was completed. The change detection algorithms include the following:

- The Normalized Difference Built-up Area Index (NDBI); and
- The Normalized Difference Vegetative Index (NDVI)

These techniques are performed in LULC studies and supported in literature by Al-doski, (2013); Varshney, (2013); Guha, (2014) and Li, (2018).

7.8.1 The Normalized Difference Built-up Index (NDBI)

NDBI is an effective technique utilized in spatio-temporal mapping changes in urban landsacape/built-up areas over time (Varshney, 2013). According to Immitzer, (2016), the NDBI technique is utilized to automate the mapping of buiilt-up areas at BCMM, through the exploration of the quantitative correlations between them. For this study, the arithmetic manipulation of re-coded NDBI images derived from Landsat 5 of 1998 and 2008, as well as Landsat 8 OLI TM imageries of BCMM of 2018 were carried out in ArcGIS 10.8 environment. Further, NDBI analysis is carried out due to the fact that it is very suitable for the quantitative study of land-cover types, and is based on the calculated difference between middle-infrared band (MIR) and Near-Infrared (NIR) bands of remotely-sensed imageries (Sharma, 2015; Karanam, 2017). The utilization of NDBI in urban studies is consistent in literature with references such as Selvam, (2012); Varshney, (2013); Sharma, 2015; Mbolambi, (2016); Karanam, (2017) and Mohamed, (2017). The NDBI images are depicted in the Figure 34.

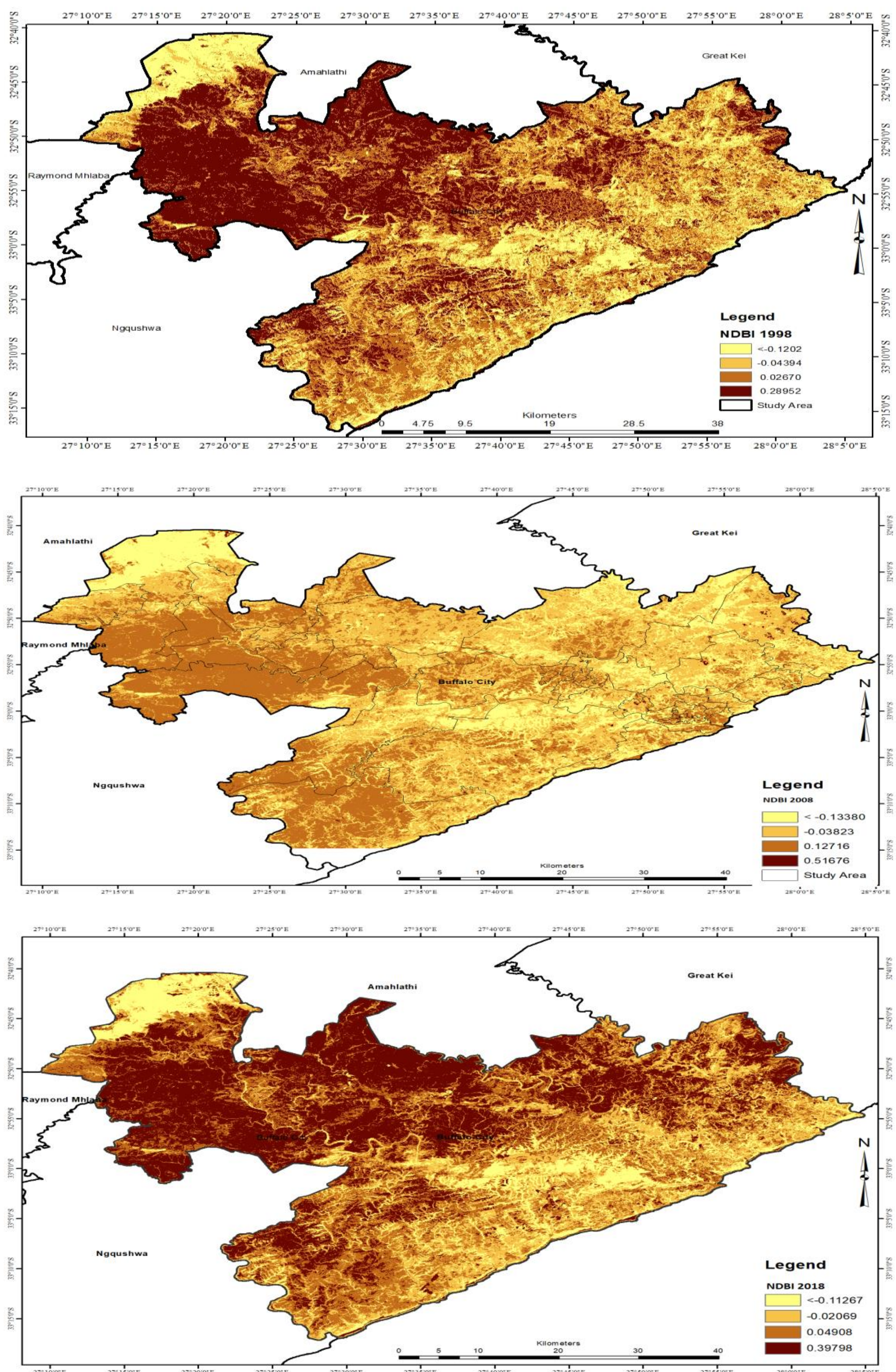

Figure 34: NDBI Images for the Study Area from 1998-2018

Figure 34 reveals the NDBI results of the study area for 1998, 2008 and 2018 respectively. The Normalize Difference Build-up Index value lies between -1 to +1. Negative value of NDBI represent water bodies, whereas, higher values represent built-up areas. NDBI value for vegetation is low. The NDBI results reveal a rapid increase in urbanization which spread mainly from the north-western parts of Dimbaza, King Williams Town to the north-western, north-central, north-eastern, south-western and coastal areas of Hanover, Perelton, Berlin, Quigney, Gonubie, Mdantsane and Bisho, with a significant increase over the years. From the foregoing, urban expansion in the study area are manifested by changes in the spatial configuration of landscape from 1998 to 2018 characterised with paving, vegetation removal during construction among others. This is further established in Chapters 2, 4 and 6 of this thesis, and confirmed by Turok, 2012; Sinyuka, 2017; Kalumba, et al, 2018). The rapid urbanization witnessed in the study area also explains the decline in coastal vegetation as seen from the NDBI results.

7.8.2 The Normalized Difference Vegetative Index (NDVI)

According to Lillesand, (2014), NDVI is a frequently adopted technique in vegetation LULC mapping and monitoring, and it involves the assessment of the red and NIR bands from RS imageries which are derived from Landsat satellite. The NDVI procedure evaluates the degree of robustness or vegetal health of the vegetation LULC that is being observed. The procedure for carying out NDVI for this study is as follows:

The signature of different features (that is, training sites) were selected and digitised on the image. The selection of signature was based on field knowledge gathered through ground-truthing exercises as well and features on the ground were confirmed from the satelite imageries. The obtained signatures served as the tool for digital image classification. Thereafter, BCMM was classified into five classes, and training samples were refined, based on the quality of results, until a satisfactory result was gotten. Subsequently, the classified images were recorded to their individual classes, namely water bodies, barren land, lowly vegetated areas and densely vegetated areas. Thereafter, NDVI was calculated on ArcGIS 10.8 software. The results for the three years were then compared, showing significant LULC at BCMM for the 20-year a period. The NDVI technique conforms with Singh, (2016), and are depicted in Figure 35.

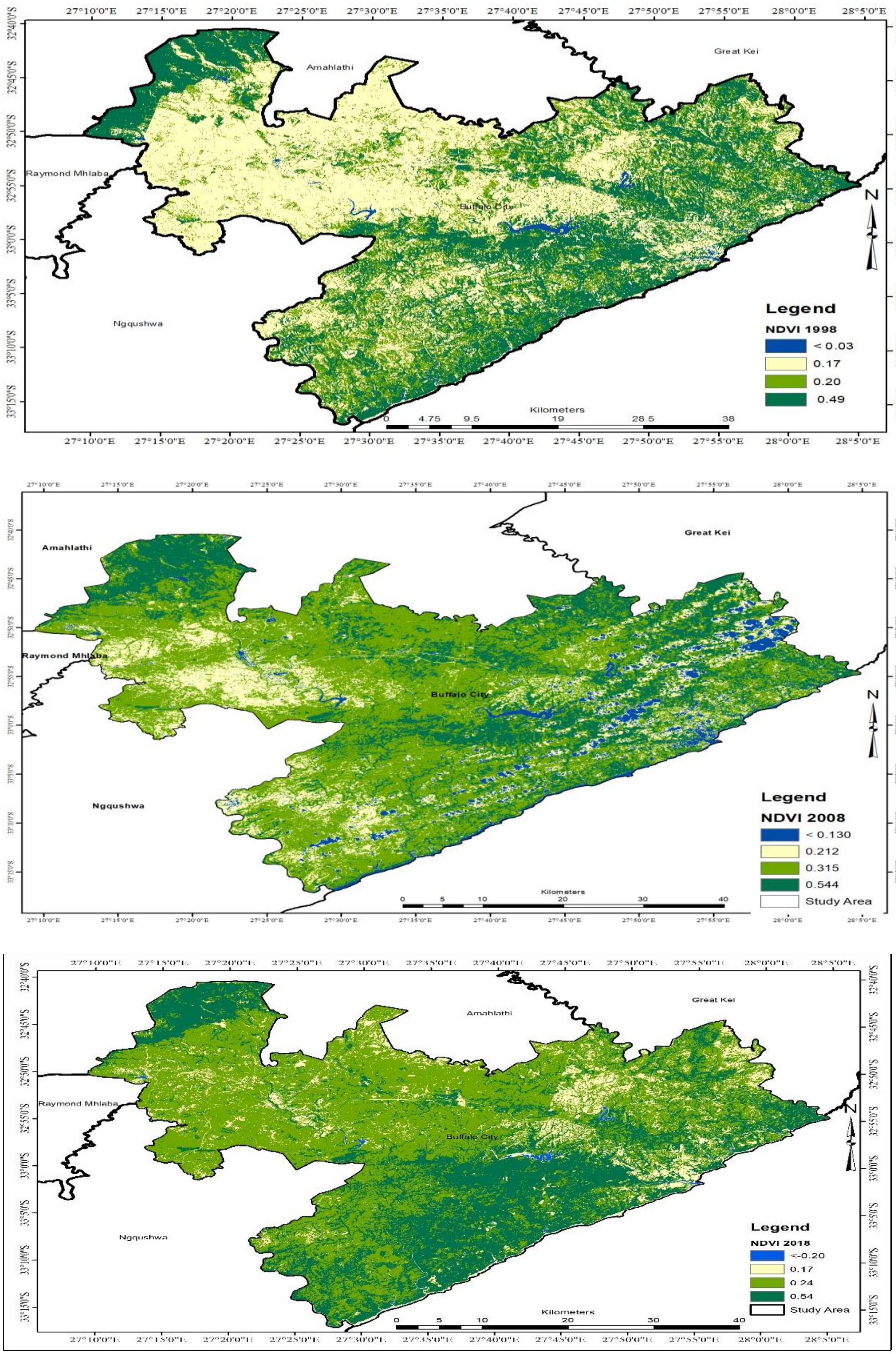

Figure 35: NDVI Images for the Study Area in 1998, 2008 and 2018

Figure 35 reveals the NDVI images for the study area, which depicts values ranging from +1.0 to -1.0. The NDVI technique is a pixel-wise mathematical calculation which was performed on the imageries of the study area using the ArcGIS 10.8 software tools. It is an indicator of plant health, calculated by comparing the values of absorption and reflection of red and near-infrared light.The NDVI values were categorized into four main classes namely water, no vegetation, sparse vegetation and dense vegetation respectively. Consequently, sandy areas, water bodies and barren rock depicted very low NDVI values of 0.1 or less. NDVI values between 0.2 and 0.4 correspond to areas with sparse vegetation; moderate vegetation tends to vary between 0.4 and 0.6, while high NDVI values ranging from 0.6 to 0.9 depict forest vegetation indicate the highest possible density of green leaves, and are at their peak stages of vegetal growth, and these are found around Nahoon, Gonubie, parts of Bisho, etc.

7.9 ACCURACY ASSESSMENT OF LAND COVER CLASSIFICATION OF STUDY AREA

The purpose of accuracy assessment is to measure the correlation between classified imageries and what exists on the ground (Schowengerdt, 2012), and this assessment conforms with Klemas, (2013). Accuracy measurements were used to verify the exactness for the NDBI and NDVI classified images of BCMM in 1998, 2008 and 2018, as also posited by Sharma, (2015) and Tavares, (2019). In order to ascertain the validity of the NDBI land cover classification results for this study, two accuracy assessment tests were performed, namely:

- Coefficient of determination (R^2);
- Cohen's Kappa Coefficient (k); and
- Pearson's Product Moment Correlation Matrix (*P* Value)

7.9.1 Accuracy Assessment Using Coefficient of Determination (R^2)

According to Nakagawa, (2017), the Coefficient of Determination (R^2) quantifies the proportion of variance. This coefficient takes values from 0 to 1 and indicates the robustness or strength of phenomena been studied (Nakagawa, 2017). The coefficient of determination technique for this study was done by testing the performance and correlation of the landcover types to the NDBI results, and this was carried out in Microsoft Excel environment. The result is presented in Figure 36.

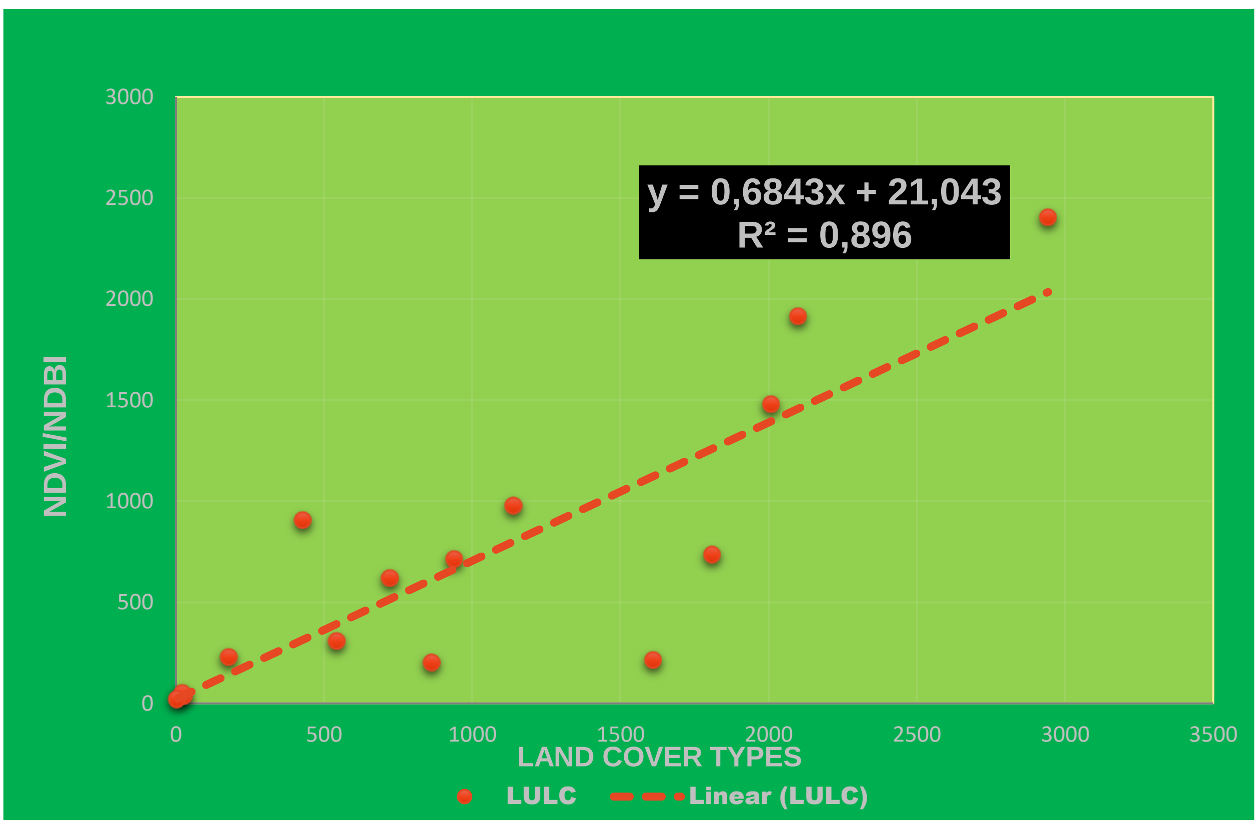

Figure 36: Coefficient of Determination (R^2) Results of BCMM Land-Cover Classification

Figure 36 depicts the coefficient of determination (R^2) of the landcover classes (X axis) for 1998, 2008 and 2018 and the NDBI/NDVI results (Y axis). Based on the regression analysis, the result indicates that the relationship between the LULC and the NDBI is significant and strongly correlated at *R^2 =0.896 (89.6%).* From the foregoing, R^2 is close to 1, which means that the results from this study show very good overall classification accuracy during the study period. This accuracy assessment technique is supported in literature by Klemas, (2013) and Tavares, (2019).

7.9.2 Accuracy Assessment Using Cohen's Kappa Coefficient (k)

Cohen's Kappa Coefficient (k) is a statistical technique which was used in the determination of accuracy levels of the five LULC classes of the study area, namely forest, grassland, water bodies, bare land and built up areas. It is generally thought to be a more robust measure than simple percent agreement calculation, since k takes into account the agreement occurring by chance. The kappa coefficient measures the agreement between classification and truth values. A kappa value of 1 represents perfect agreement, while a value of 0 represents no agreement. In essence, the kappa statistic is a measure of how closely the instances classified by the machine learning classifier matched the data labelled as ground truth, controlling for the accuracy of a random classifier as measured by the expected accuracy. The Cohen’s Kappa Coefficient was calculated using the ArcMap Raster Calculator in the ArcGIS spatial analyst. The results are presented in Tables 18 to 23.

Table 18: Kappa Coefficient Accuracy Assessment (1998)

Class	Waterbody	Built-up Areas	Forest	Bare land	Grassland	Total
Waterbody	42	0	0	0	0	42
Built up Areas	6	44	0	2	0	52
Forest	0	4	41	8	6	59
Bare land	3	2	6	39	14	64
Grassland	2	0	3	7	37	49
Total	50	50	50	50	50	250

Overall Accuracy = (203/250) = 81.2%
Kappa Coefficient = 0.77

Table 19: Producer & User Accuracy Assessment Results (1998)

Classes	Error of Commission (%)	Error of Omission (%)	Producer Accuracy (%)	User Accuracy (%)
Waterbody	0	22	78	100
Built up Areas	18	12	88	84
Forest	31	18	82	69
Bare land	44	34	66	56
Grassland	29	40	60	71

Table 20: Kappa Coefficient Accuracy Assessment (2008)

Class	Grassland	Forest	Waterbody	Bare Ground	Built Up Areas	Total
Grassland	43	0	0	3	1	47
Forest	7	39	10	2	0	58
Waterbody	0	4	37	1	0	42
Bare Ground	0	0	0	27	1	28
Built Up Areas	0	8	3	16	48	75
Total	50	51	50	49	50	250

Overall Accuracy = (194/250) 78%
Kappa Coefficient = 0.72

Table 21: Producer & User Accuracy Assessment Results (2008)

Classes	Error of Commission (%)	Error of Omission (%)	Producer Accuracy (%)	User Accuracy (%)
Grassland	9	14	86	87
Forest	23	12	88	77
Waterbody	02	16	74	93
Bare Ground	04	36	54	96
Built Up Areas	26	04	96	74

Table 22: Kappa Coefficient Accuracy Assessment (2018)

Class	Grassland	Forest	Waterbody	Bare Ground	Built Up Areas	Total
Built-up Areas	42	0	0	5	0	47
Forest	0	42	3	0	6	51
Waterbody	0	0	45	0	0	45
Bare land	8	0	1	40	0	49
Grassland	0	8	1	5	44	58
Total	50	50	50	50	50	250

Overall Accuracy = (213/250) 85%
Kappa Coefficient = 0.79

Table 23: Producer & User Accuracy Assessment Results (2018)

Classes	Error of Commission (%)	Error of Omission (%)	Producer Accuracy (%)	User Accuracy (%)
Built-up Areas	38	06	84	73
Forest	29	12	84	78
Waterbody	21	05	90	82
Bare land	32	11	80	70
Grassland	23	09	88	79

Tables 18 to 23 depict the Cohen's Kappa Coefficient results, as well as the producer/user accuracy assessment results for the five classes of built-up areas, bare land, forest, grassland and water bodies, calculated for the 1998, 2008 and 2018 imageries. Cohen suggested the Kappa result be interpreted as follows: values ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement. The results indicate substantial accuracy results of 0.77, 0.72 and 0.79 respectively for the three years under review repectively. Further, the producer and user accuracy assessment results (depicted in Tables 20, 22 and 24) were significant. The User's Accuracy is the accuracy from the point of view of a map user, not the map maker. the User's accuracy essentially tells us how often the class on the map is actually present on the ground. This is referred to as reliability. Hence, the user accuracy results for the LULC classifications for this study are significantly reliable.

7.9.3 Accuracy Assessment Using Pearson's Product- Moment Correlation Matrix (PPMC)

PPMC technique is used for investigating the relationship between two quantitative, continuous variables (Li, 2013) The nearer the scatter of points is to a straight line, the higher the strength of association between the variables. PPMC was performed using the Statistical Package of the Social Sciences (Version 26) software, and the results indicate that the NDBI/NDVI indices is very significant and highly correlated at p= 0.85 (85%). are tabulated in Table 24.

Table 24: PPMC Matrix Validating BCMM Landcover Types and NDBI/NDVI Classification Results

		NDBI/NDVI	LULC
NDBI/ NDVI	Pearson Correlation	1	.860**
	Sig. (2-tailed)		.000
	N	15	15
LULC	Pearson Correlation	.860**	1
	Sig. (2-tailed)	.000	
	N	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

Based on the PPMC matrix, the results as shown above indicates that the relationship between the LULC and the NDBI/NDVI indices is very significant and highly correlated at p= 0.86 (86%). According to Nakagawa, (2017), a correlation of 1 indicates a perfect positive correlation, hence, the results show excellent overall classification accuracy during the study period. This accuracy assessment technique is supported in the literature by Guha, (2018) and Tavares, (2019).

7.10 DISCUSSION OF RESEARCH FINDINGS

The results indicate that the CVEs of the study area have been under manifold pressures on account of urban expansion. The coastal vegetation has been degraded severely and land has been fragmented and converted into various land uses. From the foregoing, the research results of this chapter further validates empirical evidence from the BCMM respondents. The study depicts a significant increase in grassland and forest vegetation loss during the time period. Reasons attributtable to reduction in forest vegetation in the study area include rapid increases in the provision of urban infrastructure such as housing units, roads, rail and airport. in the industrial, commercial, technological and logistic centers in the study area such as Mdantsane, Bisho, King Williams Town, East London, Duncan Village, as well as the enactment of regional policies attempted to divert population and growth. Hence, policies such as the Integrated Development Plan (IDP) and the Spatial Development Framework (SDF) have led to increased urbanization has led to the removal of vegetation on account of providing basic infrastructure to meet the needs of the ever-increasing citizenry (Turok, 2012).This is also in conformity with the research findings of Orimoloye, (2018), who stated that rapid urbanization and land cover changes have occurred in many parts of the study area such as East London metropolis, and these have contributed significantly to drastic change in the natural land surface characteristics (as well as increased land surface temperature and surface solar radiation), thereby culminating into vegetation cover decline in East London area by about 358.812km^2 while built-up areas increased by 175.473km^2 from 1986 to 2006. Further, urban expansion has culminated in rapid population growth in the study area, and as supported in literature by Olatoye, (2019), it is observed that population increase could be an indispensable factor that causes urban expansion. For instance, several peripheral satellite towns (such as KWT, East London, Bisho), were connected with other commercial centres in the study area in 1998, however by 2018, they were joined more closely with the commercial centres during the process of urban expansion.

The loss of vegetation and forest will negatively affect the study area, and this affirmation is supported in literature by Cui, (2012); Goble, (2014); Acheampong, (2015); David, (2018). It can also be indicated that increased urbanization (built-up, open surface and bare surface characterizing the study area) has resulted in environmental degradation, change in the micro-climatic conditions, loss of habitats, depletion of biodiversity as well as environmental injustice (Gomera, 2018). Urban heat island effect is a major effect arising from the loss of vegetation in the study area (Orimoloye, 2018). In addition, some other factors such as air quality and urban carbon cycle can also be hampered due vegetation degradation, hence, there should be a balance between urban expansion and urban ecological conservation, which should be properly monitored and carefully addressed in the course of urbanization. LANDSAT thematic imageries have been utilized by different scholars in LULC mapping and monitoring, such as Kennedy, (2010); Zhang (2011); Sarkhosh, (2012); Avelar, (2013); Klemas, (2013); Li, (2013); Probeck, (2014); Taubenböck, (2014), Rapinel, (2015); Rawat, (2015); McCarthy, (2015); Kpienbaareh, (2018), and the imageries are free and readily available on the USGS portal.

7.11 CONCLUSION

Recent evidence shows that human-induced changes in LULC over the last 150 years have led to the release of an enormous amount of carbon into the atmosphere. LULCC may have positive or negative effects on human well-being and can have intended or unintended consequences. Further, the conversion of CVEs to croplands had provided food, fiber, fuel, and a host of other products to an increasing human population throughout human history in general, and to BCMM in particular. At the same time, urban expansion has led to reduced biodiversity, degraded watersheds, increased soil erosion, and consequently raised the risk of endangering the fragile BCMM CVEs. Owing to the rapid and unprecedented land-use/land-cover change in BCMM in recent years (as explained in the analysis section of this chapter), negative consequences such as soil erosion, loss of biodiversity, water pollution, and air pollution have increased. Hence, it is on this premise that this study examined the impact of urban expansion on the coastal vegetation of Buffalo City Metropolitan Municipality, South Africa using geospatial technologies, with focus on three different time scenes of 1998, 2008 and 2018 respectively. From the foregoing, this chapter analysed LULCC detection studies of the study area. From the foregoing, the researcher reviewed empirical studies on LULC change detection, and presented a diagrammatic explanation of the methodology adopted for this study. The RS images were downloaded from the website of the United States Geological Survey. These images were analysed through supervised means of classification utilizing the maximum likelihood approach in ArcGIS 10.8 software.

The false colour composite of the images for the years under review were generated, and thereafter, the BCMM imageries were classified into five different categories specifically dense vegetation, moderate vegetation, urban areas, water bodies and bare ground. In the course of analysing the satellite images of the study area, it was observed that vegetation is giving way to urban development. Laying credence to this, the spatial distribution of the LULC of the study area revealed that during the period under review, the urban areas had expanded in the period under review. This multiplication of urban areas is due to unplanned and arbitrary growth in certain parts of the metro municipality, which is typical to urban communities in third world economies. BCMM also witnessed an increase of built-up environments along with an attendant decline in coastal vegetal resources. Consequently, urban expansion at BCMM has led to uncontrolled threat to the coastal ecosystem; culminating into the extinction of endemic species; loss of habitat for wildlife, as well as disruption of microbial activities, and soil metabolism required for vegetal growth. Other resultant effects of urban expansion to the BCMM CVEs include: change in the micro-climatic conditions of the study area, soil erosion, environmental pollution (through illegal dumping of solid waste), loss of vegetation LULC to other land use types, among others. It is on this premise that this study makes a clarion call to the municipality administrators to urgently address these critical environmental issues. The chapter was concluded by validating the LULC and NDBI results, through the performance of Coefficient of Determination (R^2), Pearson's Product Moment Correlation (P) tests, as well as the Cohen's Kappa Coefficient, and the three tests revealed very good and highly correlated overall classification accuracy results during the study period. In conclusion, the research findings of the chapter conforms to research findings derived in Chapters 4 and 6 respectively. Hence, the trend of coastal vegetation LULC changes found in this study, especially percentage increases in deforested land and decreases in coastal vegetation cover will be useful to policy makers to take appropriate decision in ameliorating the situation and to conserve the CVEs in the study area. This study proceeds to Chapter 8 to encapsulate the overall conclusions and recommendations for the entire thesis.

CHAPTER EIGHT

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 INTRODUCTION

This doctoral study investigated the effects of urban expansion on coastal vegetation ecosystems conservation and functioning in Buffalo City Metropolitan Municipality, Eastern Cape Province, South Africa. Thus, this scholarly research is apt, relevant, appropriate, timely and the first of its kind in respect ecosystem functioning and the impact of urban expansion on CVEs in the study area. The motive for selecting BCMM for this research is its consideration as a fragile ecological space, which brings to the fore a scientific elucidation of the environmental alterations of the coastal vegetation resources of the study area from the colonial to the post-colonial era. Four key study objectives were set for the study, namely :

- To critically investigate the performance and implementation of the Integrated Development Plan (IDP) and the Spatial Development Framework (SDF) plans of BCMM.
- To investigate the obtainable ecosystem goods and economic benefits derivable from the study area;
- To determine the impact of urban expansion on the loss of coastal vegetation at the study area.
- To determine the aerial extent land use and landcover change (LULCC) at BCMM from 1998-2018 using geospatial technologies.

The set objectives guided the data collection and research procedure adopted for the study. In a bid to analyze the study objectives, empirical and theoretical literature on ecosystems functioning, the impact of urban expansion on the conservation of CVEs as well as related issues in BCMM were sourced from journal articles, books and online databases. It is germane to state that sourced literature for this study is rich, diversified and developed based on relevant themes. Further, the review raises some fundamental issues that can provoke scholarly debates in the environmental field as regards coastal ecosystems, benefits and challenges. This thesis was organized according to the study objectives, variables gleaned from the Urban Green Sustainability (UGS) Theory underpinning the study and broader issues to the research problem. The Urban Green Sustainability (UGS) Theory served as the theoretical platform to stimulate ecosystem health and resilience, consolidate efforts on biodiversity conservation and enhance ecosystem services. UGS also advances the integration of spatial planning efforts through the identification of multi-functional zones and incorporating ecosystem restoration procedures and processes into land-use planning and policy documentation which is sine-qua-non in South African coastal biodiversity conservation.

The study entails the utilization of mixed methods with the survey design. The required data for this research was exclusively designed, branded and appraised through quantitative and qualitative means, as these two procedures, (that is quantitative and qualitative) both provided high complementarity levels, validity and veracity in the course of generating the broad collection of requisite information, and favoured data comparison in the course of carrying out this research. Hence, this study pertinently and satisfactorily exhibits mastery of utilized methodological techniques.

The perception of respondents' on coastal vegetation resources is very germane to this study. From the foregoing, it is essential to state that the respondents were majorly experts, while others had indigenous knowledge on biodiversity conservation and ecology in the study area. Hence, their contributions to the research findings are authentic and highly significant. It was very important to Secondly, the advocacy for biodiversity conservation measures by inhabitants would be a mirage if the perception of the inhabitants were not assessed and incorporated in this study. Thirdly, the perception of respondents on CVEs helped to generate 12 research hypotheses on the impact of ecological conservation education on ecosystems functioning and anthropogenic interventions respectively; based on reliable data received from BCMM respondents, and were statistically proved significant. All the aforementioned reasons validate the importance of respondents perception in this study. The next section summarizes the key research findings obtained in this study.

8.2 SUMMARY OF KEY RESEARCH FINDINGS

This study is the first to explicitly investigate the effects of urban expansion on coastal vegetation ecosystems conservation and functioning in Buffalo City Metropolitan Municipality, Eastern Cape Province, South Africa. Additionally, the study demonstrated the utilization of geo-spatial technologies in the analysis of Landuse Landcover Change LULCC detection of the BCMM ecological space, and these were presented in the eight chapters of this study. Also, the problem statement, research questions, objectives and significance of the study were clearly elucidated. An outline of methods and Urban Green Sustainaibility (UGS) Theory were also provided. This theory supported ecosystem functioning and the impact of urban expansion on the conservation of CVEs in Buffalo City Metropolitan Municipality, South Africa. Chapter Two provides a review of related literature and also on broader issues concerning Empirical and theoretical literature on ecosystems functioning, the impact of urban expansion on Coastal Vegetation Environments, as well as demonstrating the utilization of geo-spatial technologies in the analysis of Landuse Landcover Change LULCC detection of the BCMM ecological space is found especially in journal articles and online databases. This chapter is organized according to the research objectives, variables gleaned from the UGS Theory underpinning the study in the chapter and broader issues to the research problem. The review of the literature is therefore organized around the following themes (1.) Ecological benefits of Coastal Vegetation Environments (CVEs); (2.) Classification of coastal ecosystems; (3.) Conceptualization of urbanization; (4.) Consequences of urban coastal vegetation land cover change; (5.) Schools of thought on urban coastal vegetation land cover change; (6.) Remote sensing applications in urban coastal land cover change detection; (7.) Impact of urban expansion on CVEs; (8.) consequences of urban expansion on South Africa's CVEs; (9.) BCMM ecological environment status; and, (10.) Quest for an optimum coastal vegetation conservation and urban sustainability. The literature reviewed in this chapter is organized according to themes based on the study objectives, UGS Theory, and broader issues involving the research problem. In Chapter Three, the research methodology is discussed, focusing on the research methods, research design, study population, sampling procedure, data collection procedures, data analysis, validity and reliability of research instruments. Chapter Four presents a critical assessment of the performance and implementation of the integrated development plan and spatial development framework regarding the conservation of the coastal vegetation of Buffalo City Metropolitan Municipality (BCMM)

Chapter Five provides the discussion on ecosystems functioning and conservation of ecological goods and services in BCMM. Chapter Seven elucidated the geo-spatial analysis of LULCC detection of CVEs in BCMM, while Chapter Eight presents the overall summary of the findings, conclusions and recommendations of the study. The key research findings obtained for each of the study objectives are summarized in the next section.

A Critical Assessment of the Performance and Implementation of the Integrated Development Plan (IDP) and Spatial Development Framework (SDF) of BCMM (Study Objective One)

Sequel to the consequences of the post-apartheid policies on spatial development of south African urban space, BCMM inclusive, which is characterized by disintegration, uneven accessibility to public amenities, occupations as well as social facilities; this colossal unevenness culminated in spatial management problems, in addition to social disintegration problems in the urban areas of the metro. The SDF and IDP policy framework serve as a germane urban spatial instrument for development and ensuring more viable and sustainable ways of meeting the economic, social, and material needs of the study area. Further, the two aforementioned documents have fostered developmental strides in the spatial organization of the municipality through the enactment of spatially-sustainable development goals and supporting programmes, as well as endorsing sound planning objectives according to the relevant policies. In line with the aim of this research, which is centered on urban expansion, CVEs and conservation in BCMM, the IDP and SDF policy framework have significantly enhanced the re-ordering of the former BCMM apartheid space into a more efficient, productive and spatially balanced metropolitan area. This is analysed in the NDBI analysis in Chapter Seven, which shows urban expansion to several parts of the study area. On the other hand, the urban coastal areas have witnessed vegetal losses on account of the establishment of development nodes and extension of urban edges (refer to the analysis of field results in Chapters Six and Seven for confirmation), as recommended by the IDP and SDF policy framework. Further, the functioning of ecosystems goods and services have improved on account of the implementation of the IDP and SDF policy framework of the study area. These assertions are further confirmed through analysis of fieldwork in Chapters 5, 6 and 7 respectively. In concluding this chapter, it is opined that despite the positive contribution of the SDF and IDP policy framework to the spatial and economic development of the study area, it is evident that the implementation of the policy documents is still lacking as regards constant monitoring of urban expansion activities, which is still largely uncontrolled. For example, the CVEs in the study area are largely degraded because of urban expansion, as witnessed in the coastal areas of the Nahoon Nature Reserve, Quigney, and so on.

Ecosystems Functioning and Conservation of Ecological Goods, Services and their Economic Benefits in BCMM (Study Objective Two)

A synopsis of this study objective reveals the types and importance of the ecological systems in the study area, and this was presented through the analysis of questionnaire results based on three categories of ecosystem services provided by the study area, namely provisioning, cultural and regulation services, of which 254 copies were retrieved from different categories of individuals in the study area. The study reveals the benefits derivable from the study area, and these were categorized into three areas namely: raw materials, medicinal purposes and economic benefits. In addition, the type of changes in the ecosystem were analysed, and the respondents acknowledged changes in the overall quality, species abundance, as well as changes in ecosystem diversity. Laying credence to this, the respondents stated that ecosystem resources had decreased in the study area (this result is confirmed in Chapters Six and Seven).

Impact of Urban Expansion on the Conservation of Coastal Vegetation Environments in BCMM (Study Objective Three)

This topic presents the analysis of results gathered from the distributed survey questionnaires, and the key findings of this study objective indicate that the causes of coastal vegetation loss include urban expansion, deforestation, global warming, climate change, crop cultivation, and government policy. This outcome forms part of the culminating effects of the SDF and IDP implementation in the study area (as discussed in Chapter Four, which was further confirmed in the analysis of this chapter). The results indicate that 178 (78%) respondents mentioned uncontrolled urbanization as the major environmental challenge in the study area. Further, results indicate there are various kinds of anthropogenic interventions taking place in BCMM namely: the erection of informal settlements, land development, illegal tree felling, bush fires, as well as the conversion of ecosystem land uses for crop cultivation.

Geospatial Analysis of Landuse Landcover Change (LULCC) Detection of Coastal Vegetation Loss at Buffalo City Metropolitan Municipality from 1998-2018 (Study Objective Four).

This chapter analysed BCMM LULC changes, and the results indicate that urban areas in the study area had expanded from 199.16km^2 in 1998 to 2,400.7km^2 in 2018, as well as a decrease in dense vegetation from 903.68km^2 in 1998 to 226.4km^2 in 2018, and these results confirm evidence in literature in Chapter 2 and research findings in Chapter 6. Additionally, Normalized Difference Built-Up Index (NDBI) and Normalized Difference Vegetative Index (NDVI), to further authenticate the correctness of the LULC classification figures. The author further validated the LULC and NDBI/NDVI results by carrying out the coefficient of determination (R^2), Kappa coefficient, and Pearson's Product Moment Correlation (P) tests, and all tests revealed very good and highly correlated overall classification accuracy (of R^2=0.89 and P=0.86 respectively) during the study period.

8.3 SUMMARY OF DISCUSSIONS

The Spatial Development Framework (SDF) and Integrated Development Plan (IDP) are formulated for the main purpose of redressing the imbalances generated by the apartheid regime. The IDP and SDF are documents that address future developmental opportunities and challenges of municipalities and are channelled by realistic goals that are contextualized in order to actualize the vision and statements of the municipality. Also, Spatial planning in BCMM has evolved since the 1994 South African post-apartheid period. Further, the spatial development of the study area is in progress, as urban renewal initiatives, which has been prioritized into three categories is been expedited around East London CBD, Quigney, sleepers site, west Bank, Bisho Berlin and parts of King Williams Town. Also, there is an uneven distribution of population in favour of areas such as East London, when compared to areas such as Duncan village, Amalinda, Abbotsford, Nahoon Valley, and so on. This colossal unevenness is resultant from the spatial fragmentation of BCMM space, which has concomitantly resulted in spatial management problems as well as social disintegration problems in the urban areas of the metro, especially as buffers often partition different vicinities in the study area.

Despite the positive contributions of the SDF and IDP spatial policy framework, to the development of BCMM, it is empirically evident that there is a lack of visible implementation of the biodiversity conservation policies in the SDF and IDP documents. This has resulted in uncontrolled anthropogenic interventions, such as unmonitored urban expansion activities, which is, still largely uncontrolled, and this has adversely culminated in the reduction in coastal vegetation and wildlife species overall quantity and ecosystem diversity; disruption of biogeochemical cycles and CVEs scenic beauty; increase in soil erosion, and reduced soil precipitation, and the gradual disappearance of wildlife habitat. It is on this premise, therefore, that this study emphasizes the urgent need for local authorities to monitor and ensure strict compliance with biodiversity legislation and conservation policies geared towards the sustainability of coastal ecosystems functioning in the study area.

The research on the conservation of ecological goods, services and ecosystems functioning at BCMM reveals that while the majority of respondents have knowledge of coastal resources and the environment, many others still claim ignorance of the significance of ecological resources, hence, this thesis is long overdue, as urgent strategies towards the orientation of the populace on the importance of conserving CVEs and environmental resources should be expedited. Further, the respondents derive medicinal benefits from plants grown in the study area for the treatment of ailments and diseases such as measles, hypertension and insomnia. The cultural ecosystem services provided in the study area namely Erosion control, hydrological regulation, climate regulation, soil/water/air purification, waste treatment, flood buffering, habitat maintenance, carbon sequestration and coast stabilization functions.

The study also revealed that urban expansion has significantly depleted the coastal vegetation resources in the study area. Other causes of coastal vegetation loss include deforestation, crop cultivation, government policies, climate change and global warming. Further, this study reveals that the reasons for urban expansion include agriculture, the need for development and population growth. In order to proffer solutions to uncontrolled urbanization as well as the degradation of CVEs, and control strategies were proposed in this regard, and these include controlled population growth, limiting urban expansion as well as the implementation of the coastal ecosystem conservation laws.

The geospatial analysis reveals the presence of 5 major types of the LULC types in the study area image namely bare ground, dense vegetation, moderate vegetation, water bodies and built-up areas**.** The analysis further reveals that built-up areas occupy about 70% of the total LULC. For example, the total urban area increased from 202.17 km^2 in 1998 to about 2403.7 km^2 in 2018, which is more than ten times. However, on the contrary, dense vegetation decreased, from around 905 km^2 in 1998, down to 229.4 km^2 (about 676.3 km^2 loss). From the foregoing, urban expansion in the study area are manifested by changes in the spatial configuration of the landscape from 1998 to 2018 characterised with paving, vegetation removal during construction among others.

8.4 SUMMARY OF RESEARCH CONTRIBUTIONS TO THE DEVELOPMENT OF SCIENCE

This study contributes to science in several ways such as the supply of knowledge regarding LULC dynamics, as well as providing scientific and academic support to land users and policy makers in their decisions. LULC studies enhance the assessment of complex spatio-environmental interactions, causes and responses in order to better project future trends of anthropogenic activities and LULC change. If LULC changes are not carried out scientifically, the negative impacts on both the environment and the socio-economic settings are not easily quantifiable. This has been particularly important, as changes in LULC become more rapidly affecting man-environment spatial interactions. Thus, understanding LULC dynamics is germane in taking corrective actions on the use of land for sustainable productivity.

Second, this study contributes to science through the enhancement of knowledge on ecological systems by promoting measures geared towards ensuring the functionality of all components of the ecosystem, such as vegetation, air, water and wildlife. In the same vein, the study makes a clarion call towards promoting ecological conservation through the regulation of water, soil, biodiversity, carbon fixing, surrounding wildlife habitat, in addition to offering several ecological benefits in urban areas. Further, this study significantly contributes to scientific knowledge with regards to ecosystem services in changing landscapes, synergistic interactions of provisioning, regulating, as well as cultural ecosystem service provisioning at local and regional levels. Additionally, the assessment of responses on ecosystems services and changes to the landscape changes and the development of place-based theories on ecosystems services are actualized (as performed in the analysis of chapter five).

Third, this study contributes to science by advancing the course of landscape sustainability through simultaneous maintenance and improvement of biodiversity, ecosystems services, policy impacts and general human well-being (as analysed in chapters two, four and five). Put differently, the study, the study encourages sustainable LULC planning in order to mitigate the negative effects of land use and to ensure the efficient use of environmental resources with minimal adverse impact on future generations. This study also promoted alternative ways of sustaining ecosystems functioning particularly through ecological conservation of endangered and endemic ecosystems resources and its relationship to landscape sustainability. This study also brings to the fore the growing complexity of environmental sustainability problems in a former apartheid space (as characterized by coastal urbanization and the intricacies of vegetation conservation), as elucidated in chapters two, four, six and seven.

Forth, this study adds to the inventory of existing scientific knowledge on the utilization of multi-temporal satellite-derived environmental data and other thematic raster data, which have significantly contributed to environmental modelling (as demonstrated in chapter seven). In combination with GIS techniques, the study provides a viable platform for assessing spatio-temporal trends of development. In addition, the study established the utilization of LULC change detection methods using satellite imageries and the analytical functions performed in the GIS environment, which enhanced the determination of patterns and processes influencing significant changes in LULC.

Fifth, this study enhances the development of early warning systems as well as remedial solutions to address invasive vegetation species colonization as a form of environmental degradation. This thesis also serves as an empirically-tested scientific document for policy makers, educationists, city managers, ecologists, environmentalists and other stakeholders towards ensuring strict adherence to environmental resources management for sustainable utilization, vegetation conservation culture, as well as urban sustainability measures in the course of spatial development and ecological conservation. This document also serves as a working document in academia, as it emphasizes the need for higher educational institutions to include the teaching and learning of ecological science, vegetation/environmental conservation, coastal management studies, as well as environmental geography as part of their institutional curricula.

8.5 CONCLUSION

This study investigated the effects of urban expansion on coastal vegetation ecosystems conservation and functioning in Buffalo City Metropolitan Municipality, Eastern Cape Province, South Africa. In summary, the results of this study indicate that the CVEs of the study area have been under manifold pressures on account of urban expansion. The coastal vegetation has been degraded severely and land has been fragmented and converted into various land uses. From the foregoing, the research results of this chapter further validate empirical evidence from the BCMM respondents regarding environmental challenges of CVEs in the study area (as analysed in chapters six and seven) include the reduction in coastal vegetation and wildlife species overall quantity and ecosystem diversity, as well as environmental degradation and biodiversity loss in the study area.

8.6 AREAS FOR FUTURE RESEARCH

With reference to areas for future research, the effects of urban expansion on biodiversity in the study area can also be considered. In addition, an assessment of the types of endangered species in the coastal vegetation environments at BCMM on account of urban expansion can also be investigated as future research.

8.7 RECOMMENDATIONS

In view of the above, the study made specific, detailed, definite and explicit recommendations, which are geared towards ensuring sustainability in urban expansion vis-à-vis conservation of CVEs. Therefore, based on the findings of this study, the following recommendations are made:

It has been observed in the literature that the consequence of not achieving vertical integration of coastal land policy can be costly on coastal communities and lengthy. Hence, in a bid to draw from pieces of evidence and discussions presented in this study, it is suggested that there should be vertical integration of national, state and local coastal policy and planning to enable an integrated approach to integrated coastal management of BCMM. Additionally, the process of community engagement is central to any coastal planning process, which is nurtured by trust and goodwill over time. This is further enabled by the development of common objectives among coastal residents and stakeholders and a commitment to conserve the fragile coastal ecosystem over the long term. From the foregoing, community engagement activities geared towards the conservation of CVEs should be greatly encouraged in the study area, and this will concomitantly foster a communal sense of belonging regarding coastal resources conservation among BCMM dwellers, so as to find more sustainable coastal planning solutions. It is also essential to provide a key partnership and a relevant basis for environmental education and community capacity building among the inhabitants in the study area. This is because environmental education is recognised as a key strategy for increasing knowledge and understanding of CVE conservation, but needs to be appropriately funded over the long term to have any lasting effect. Also, new governance mechanisms such as intergovernmental relations need to be further explored to facilitate more sustainable coastal planning outcomes, as this can significantly facilitate sustainable outcomes.

On account of weak implementation of SDF and IDP policies in terms of controlled urban expansion and environmental degradation (as analyzed in Chapters Six and Seven), policy makers, city managers and other BCMM stakeholders should ensure strict adherence to the implementation of the IDP and SDF in the course of spatial development and ecological management of the study area. Also, environmental impact assessment must be carried out as part of the necessary conditions for anthropogenic interventions in the study area, as stated in chapter four of this thesis.

Due to the obtainable ecosystem goods and services in the study area (as reported in Chapter Five), it is germane to invest in the preservation of healthy ecosystems as well as the restoration of degraded ecosystems, further, preserving and/or restoring ecological systems in the metro municipality is sine-qua-non to decrease risks of environmental degradation. Further, as suggetsted in chapters 5 and 6 of this study, adaptation options, which are ecosystem-friendly, could be utilized in the reduction of the negative effects of climate change and anthropogenic interventions on vegetal resources, to achieve optimum delivery of ecosystem services and intensify BCMM's resilience to the adverse effects of climate change.

In view of environmental degradation and uncontrolled urbanization challenges in the study area (as presented in chapter six), improvement of conservation strategies and communal ventures aimed at proffering innovative solutions to environmental challenges in the study area.

The need to enhance the promulgation and expedition of programmes that conform to green infrastructure strategies is highly imperative. This is essential because green spaces are known to greatly improve human health and wellbeing. There should also be holistic management of all aspects of coastal vegetation resources through firm articulation and effective implementation of the SDF and IDPs. Further, the balancing of management responsibilities should be expedited for these policies to be fully operational.

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Appendix 1: PhD Thesis Review Paper Publication- Exploratory Review of Urban Expansion, Coastal Vegetation Environments (CVEs) and the Paradox of Sustainability, Journal of Human Ecology,

J Hum Ecol, 67(1-3): 21-30 (2019) DOI: 10.31901/24566608.2019/67.1-3.3152

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Exploratory Review of Urban Expansion, Coastal Vegetation Environments (CVEs) and the Paradox of Sustainability

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KEYWORDS Vegetation. Coastal Vegetation Environments (CVEs). Sustainability. Urban Expansion. Environmental Degradation

ABSTRACT Vegetation forms a fundamental proportion of resources used to determine the potential of the land on which they are sustained, unfortunately, urbanization has altered ecological systems and coastal vegetation environments all over the world, and the conservation of the endangered resource is still a serious challenge. Further, urbanization around the coastal vegetation environments is expanding at unprecedented rate, and this has resulted into more people relocating to these areas. For example, urban expansion reduces coastal vegetation, soil moisture and quality, and invariably results in poverty. From the foregoing, there is need for constant monitoring of endangered coastal ecosystems. Therefore, this paper appraises the impact, relevance perspectives threats, and challenges of coastal vegetation resources on account of urban expansion. Also, major advances and key issues relating to coastal vegetation management, as well as recommendations are discussed so as to help move the field forward.

INTRODUCTION

Coastal vegetation is core in ecosystem func- tioning and biodiversity enhancement (Brockerhoff 2017). These ecological systems rank amongst the most significant worldwide, pro- viding several ecosystem goods and services which are central to the welfare of mankind (Ade- kola and Mitchell 2011), and these include the protection of the coastal ecosystem , improve- ment of water quality, biodiversity support, fish- ery nurseries. Further, CVEs provide eco- system services which relate to local climate mit- igation, regulation and adaptation, food securi- ty (such as habitat provision, food supply and nurseries for seedlings and fisheries), occupa- tional security, and an array of social/traditional benefits, scientific knowledge, ecotourism, recre- ation, as well as the preservation/development of spiritual and cultural values. Inspite of all these merits derived from coastal vegetation environ- ments, ecosystem degradation and biodiversity loss, which greatly undermines the life's foun-dations is the abysmal phenomenon is experi- enced in CVEs (UNDP 2012). A great challenge to humanity, most especially the world's poor is the loss of biodiversity and ecosystems. It is stated in literature that over 1.1 billion humans live on less than US$ 1 daily (UNSDSN 2013; FAO 2017), and they hinge directly on coastal vegetation environments for their feeding, ener- gy needs, shelter and medical requirements, as well as ecosystem goods and services so as to sustain their livelihood (Rego 2018). Consequently, at present, over fifty percent of the world's popu- lation (that is over 3 billion inhabitants) reside around 100 km radius of a coast, which is less than 20 percent of all landmass (UNEP 2016). Also, it is assessed that over 450 million people live around the coastal zones in Sub-Saharan Africa (Sale et al. 2014). It is also epitomized in litera- ture that pressure resulting from anthropogenic factors in and around coastal vegetation envi- ronments (CVEs) has greatly sustained threat to vegetation, wildlife as well as economically im- portant micro-organic resources in most devel- oping societies, South Africa inclusive (Food and Agriculture Organization 2011; Amosu 2012). It is also elucidated in literature that the coastal environment, is the harbinger of biodiversity, as well as economic activities and leisure (Amosu 2012). For instance in South Africa, the native CVEs play germane roles regarding the stabili-

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Appendix 2: Original Article Publication **- Ecosystem Functioning, Goods, Services and Economic Benefits in Buffalo City Metropolitan Municipality (BCMM) Eastern Cape, South Africa**

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Ecosystem Functioning, Goods, Services and Economic Benefits in Buffalo City Metropolitan Municipality (BCMM) Eastern Cape, South Africa

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[1]Department of Geography and Environmental Science, Faculty of Science and Agriculture, University of Fort Hare, 5700, Alice, South Africa

[2]Department of Statistics, Faculty of Science and Agriculture, University of Fort Hare, 5700, Alice, South Africa

KEYWORDS Ecosystem Functioning. Ecosystem Goods and Services. Economic Benefits. Vegetation. Buffalo City Metropolitan Municipality

ABSTRACT This paper focused on the ecosystem functioning, goods, services and economic benefits in Buffalo City Metropolitan Municipality (BCMM) Eastern Cape, South Africa. Approval for this study was given by both the BCMM and the University of Fort Hare (with ethical clearance certificate number given as KUL011SOLA01). The analysis of results begin with the demographic characteristics of the study population (such as age, educational attainment and race), as well as other issues including the following: knowledge and benefits derived from CVEs, changes in features of coastal vegetation resources management and conservation, as well as the analysis of derivable services (such as provisioning, cultural and regulation services) in the study area. It presents the analysis of questionnaire results, which indicated that more males (122/48.2%) participated in the field exercise, while respondents that had the highest frequency in terms of age (that is, 36-40 years old respondents) were 97 (38.3%). As regards educational attainment, majority of the respondents, (that is, 117/46.1%) were university degree holders, and blacks were 172 (68.0%). This research also sought to know the

respondents’ knowledge of coastal vegetation resources, as well as the benefits derivable from the study area, and these were categorized into three areas namely, raw materials (154/56.9%), medicinal purposes (159/62.8%) and economic benefits (161/63.4%). The results were further elucidated with bar graphs, pie charts, scatter diagrams, plates and tables.

INTRODUCTION

This study focused on the functioning, goods and services as well as the economic ben- efits from Buffalo City Metropolitan Municipal- ity. In general ecosystems offer several environ- mental functions and services, such as biodi- versity conservation (Mace et al. 2012; Bom- marco et al. 2013; Breuste et al. 2013), carbon sequestration (Egoh et al. 2012; Reyers et al. 2012), defense against soil erosion (Mendoza- González et al. 2012; Ninan 2012) and also, veg- etation beautifies the environment (Reyers et al. 2012; Rao et al. 2015; FAO 2016), flood control (Sitas et al. 2014), desertification and water sup- ply (Wangai et al. 2016; Turpie et al. 2017). This calls for continued research to be undertaken, monitoring, and protection to ensure ecosys- tem functioning and services which is funda- mental in coastal green sustainability (Willemen et al. 2013; Cortinovis and Geneletti 2018). Ac- cording to Bastian et al. (2012), there are two basic areas of ecosystem functioning, firstly are the functions which offer direct advantage to man and secondly the environment. These are those which uphold natural systems integrity in general and ecosystems in specificity (Cabello et al. 2012). Also, the classifications of functions (namely, information, habitat, production and regulation functions, Egoh et al.

Appendix 3: Acceptance of Chapters 6 & 7 of PhD Thesis as Original Articles for Journal Publication

Applied Ecology and Environmental Research (AEER) Journal, Budapest, Hungary. DOI: 10.15666/aeer (http://dx.doi.org/10.15666/aeer) * ISSN 1785 0037 (Online) * ISSN 1589 1623

Manuscript ref. 8774 and 8775

Applied Ecology <aeerjournal@gmail.com>Tue, Oct 15, 2019 at 11:37 AM To: Tolu Olatoye <olatoyetolu@gmail.com>

Dear Author,
Thank you for your resubmissions.
We would like to inform you that your manuscripts (ref. 8774 and 8775) titled 1. *"Impact of Urban Expansion on Coastal Vegetation Conservation in Buffalo City Metropolitan Municipality, Eastern Cape, South Africa"* and 2. *"The Utilization of Geo-Information Technologies in the Spatio-Temporal Assessment of Buffalo City Metropolitan Municipality, South Africa"* have been accepted for publication with Open Access publication fee. We are sending you attached the payment details.

Payment should be made by bank transfer with payment instruction: "OUR" (transfer charges need to be covered by payment initiator). Please indicate the reference number of your manuscript during the transaction or send us the name of the payer. If you would like to pay the fee by bank card please indicate, and we will send you an individual link for the payment. In case you need the invoice, please send us the invoicing name and address. Publication process will continue with technical editing after receiving your payment. Thank you and best regards,
Technical Editors

Applied Ecology and Environmental Research Open Access International Scientific Journal
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Appendix 4: ETHICAL CLEARANCE CERTIFICATE

University of Fort Hare
Together in Excellence

ETHICAL CLEARANCE CERTIFICATE
REC-270710-028-RA Level 01

Certificate Reference Number:	KUL011 SOLA01
Project title:	**Urban Expansion, Coastal Vegetation Environments and Conservation: A Case of Buffalo City Metropolitan Municipality, South Africa.**
Nature of Project	Doctor of Philosophy in Geography and Environmental Sciences
Principal Researcher:	Tolulope Olatoye
Supervisor:	Dr A.M Kalumba
Co-supervisor:	Dr S.P Mazinyo

On behalf of the University of Fort Hare's Research Ethics Committee (UREC) I hereby give ethical approval in respect of the undertakings contained in the abovementioned project and research instrument(s). Should any other instruments be used, these require separate authorization. The Researcher may therefore commence with the research as from the date of this certificate, using the reference number indicated above.

Please note that the UREC must be informed immediately of

- Any material change in the conditions or undertakings mentioned in the document;
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research.

The Principal Researcher must report to the UREC in the prescribed format, where applicable, annually, and at the end of the project, in respect of ethical compliance.

Special conditions: *Research that includes children as per the official regulations of the act must take the following into account:*

Note: The UREC is aware of the provisions of s71 of the National Health Act 61 of 2003 and that matters pertaining to obtaining the Minister's consent are under discussion and remain unresolved. Nonetheless, as was decided at a meeting between the National Health Research Ethics Committee and stakeholders on 6 June 2013, university ethics committees may continue to grant ethical clearance for research involving children without the Minister's consent, provided that the prescripts of the previous rules have been met. This certificate is granted in terms of this agreement.

The UREC retains the right to

- Withdraw or amend this Ethical Clearance Certificate if
  - Any unethical principal or practices are revealed or suspected;
  - Relevant information has been withheld or misrepresented;
  - Regulatory changes of whatsoever nature so require;
  - The conditions contained in the Certificate have not been adhered to.

- Request access to any information or data at any time during the course or after completion of the project.

- In addition to the need to comply with the highest level of ethical conduct principle investigators must report back annually as an evaluation and monitoring mechanism on the progress being made by the research. Such a report must be sent to the Dean of Research's office.

The Ethics Committee wished you well in your research.

Yours sincerely

31/08/2018

Professor Pumla Dineo Gqola
Dean of Research

28 August 2018

cbo 5:- Letter of Approval from the City Manager, BCMM

1

Buffalo City Metropolitan Municipality

East London | Bisho | King Williams Town
Province of the Eastern Cape
South Africa

Website: www.buffalocity.gov.za

BUFFALO CITY METROPOLITAN MUNICIPALITY

Office of the City Manager
10th Floor Trust Centre
Cnr Oxford and North street
East London
5201

Tel: 043 705 1045
Email: Kholekas@buffalocity.gov.za

Date: 02 OCTOBER 2018

TO WHOM IT MAY CONCERN

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN BCMM: MR TOLULOPE AYODEJI OLATOYE

Dear Sir/Madam

It is hereby acknowledged that **Mr. Olatoye**, a student at **University of Fort Hare**, completing **Doctor of Philosophy**, has met the prerequisites for conducting data collection at Buffalo City Metropolitan Municipality (BCMM) for partial fulfillment of his degree. He has provided us with all the necessary documentation as per the BCMM Policy on External Students conducting research at the institution.

With reference to the letter to the City Manager dated 08 July 2018, permission was requested to conduct research at BCMM for his Research Report, entitled "**Urban Expansion, Coastal Vegetation Environments and Conservation.**" This request was scrutinised by the Information and Knowledge Management, Research and Policy Unit for further assistance, and approved in accordance with national and international research ethical and legal norms, standards and guidelines. **Mr. Olatoye** was asked to provide the Unit with the necessary documentation, which he subsequently did.

The relevant Officials to assist in the research were identified and will duly be informed about the research, and the fact that **Mr. Olatoye** has met all the prerequisites. Their contact details will also be provided to **Mr. Olatoye** and he will be informed to contact them directly for assistance.

We wish **Mr. Olatoye** good luck in his studies.

MR J FINE

....

ACTING HEAD: IKM, RESEARCH AND POLICY

MR A SIHLAHLA

....

CITY MANAGER

APPROVED	NOT APPROVED

Appendix 6

ED/R/T/0023

EDITOR'S REPORT ON PhD THESIS

TO WHOM IT MAY CONCERN

This document certifies that the PhD thesis whose title appears below has been edited for proper English language, punctuation, spelling, grammar, and overall by Adetola Soladoye, whose qualifications are listed in the footer of this certificate.

Title:

Effects of Urban Expansion on Coastal Vegetation Ecosystems (CVEs) Conservation and Functioning in Buffalo City Metropolitan Municipality, Eastern Cape Province, South Africa.

Author:

Tolulope Ayodeji OLATOYE

Date Edited:

05 May 2021

Signed:

Dr. Adetola Soladoye

B. A (*HONS*) English; PGDE; Library & Inf. Sc.; (*MLIS*) Library & Inf. Sc; *PhD*

Appendix 7: Questionnaire

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<u>Research Confidentiality and Informed Consent Form</u>

I, **Tolulope Ayodeji OLATOYE** from the Department of Geography and Environmental Sciences is asking people from your community / sample / group to answer some questions, which I hope will benefit your community and possibly other communities in the future.

I, **Tolulope Ayodeji OLATOYE** from the Department of Geography and Environmental Sciences is conducting research regarding **Urban Expansion, Coastal Vegetation Environments and Conservation. Case of Buffalo City Metropolitan Municipality, South Africa.** I am interested in investigating the uncontrolled threat to the ecological system in the study area, and hence the need to asses, monitor and prevent the threatened and endangered endemic coastal vegetation resources from. Therefore, the study will provide information to guide improvements to the management and restoration of coastal vegetation in the study area to commercial activities and local economies. This research also seeks to examine the proximate causes and underlying driving forces of coastal vegetation changes to proffer solutions towards optimal conservation and sustenance of biodiversity in the study area. Also, this study seeks to provide vivid information on threats encountered at coastal vegetation environments, such as threats due to population pressure, climate change, nutrient loading, pollution and over-exploitation. Please understand that you are not being forced to take part in this study and the choice whether to participate or not is yours alone.

However, we would really appreciate it if you do share your thoughts with us. If you choose not take part in answering these questions, you will not be affected in any way. If you agree to participate, you may stop me at any time and tell me that you don't want to go on with the interview. If you do this there will also be no penalties and you will NOT be prejudiced in ANY way. Confidentiality will be observed professionally. I will not be recording your name anywhere on the questionnaire and no one will be able to link you to the answers you give. Only the researchers will have access to the unlinked information. The information will remain confidential and there will be no "come-backs" from the answers you give. The ethical clearance number for this research is **KUL011SOLA01**.

INFORMED CONSENT

I hereby agree to participate in research regarding **Urban Expansion, Coastal Vegetation Environments and Conservation. Case of Buffalo City Metropolitan Municipality, South Africa**. I understand that I am participating freely and without being forced in any way to do so. I also understand that I can stop this interview at any point should I not want to continue and that this decision will not in any way affect me negatively.

I understand that this is a research project whose purpose is not necessarily to benefit me personally. I have received the telephone number of a person to contact should I need to speak about any issues which may arise in this interview. I understand that this consent form will not be linked to the questionnaire, and that my answers will remain confidential. I understand that if at all possible, feedback will be given to my community on the results of the completed research.

……………………………..

Signature of participant

Date……………………..

Tolulope Ayodeji OLATOYE
PhD Student,
Department of Geography and Environmental Sciences
University of Fort Hare, Alice, 5700
+27730847761
201615087@ufh.ac.za

URBAN EXPANSION, COASTAL VEGETATION ENVIRONMENTS AND CONSERVATION IN SOUTH AFRICA.

SECTION A: DEMOGRAPHIC CHARACTERISTICS

1. Gender

Male

Female

2**. Age** ……………………………………………

3. **What is your highest level of education?**

(a) No education

(b) Primary

(c) Middle school

(f) Matric

(g) University degree

(h) Undergraduate Student

(i) National Diploma

4. **Race**

(a) Black

(b White

(c) Colored

(d) Indian

(e) Asian

SECTION B: COASTAL VEGETATION RESOURCES

5. Do you know about coastal vegetation resources and the environment?

(a) Yes

(b) No

6. Do you care about coastal vegetation resources and the environment?

(a) Yes (b) No

7. Which benefits do you derive from the coastal vegetation? (Tick as many choices)

(a) Food

(b) Raw Material

(c) Medicinal purposes

d) Economic

(e) Others (Please specify)

8. In your percetion, which of these have changed regarding the coastal vegetation resources in your area?

the overall quality species abundance Ecosystem diversity Don’t Know

9. With regards to your answer in number 8, what is the degree of change? It has

Increased No change Decreased Don't know

10**.** On a scale of 1 to 10, how do you rate the management and conservation of the coastal vegetation resources in your location? (1= extremely poor; 10= Excellent), please provide your score in the box below:

SECTION C: CHALLENGES ENCOUNTERED IN COASTAL VEGETATION ENVIRONMENT

11. Are there environmental challenges in your location?

a. Yes (b) No

12. What are the causes of vegetation loss in your area? Tick as many as possible

(d) Deforestation (d) Government Policy

(e) Urban expansion (e) Climate Change

(f) Crop Cultivation (f) Global Warming

(g) Others, specify

13. On a scale of 1 to 10, How has the environmental challenges in your location affected you? (1= Extremely Adverse Impact; 10= Excellently Positive Impact), please provide your score in the box below:

14. Select the anthropogenic activities that take place in your location:

(a)Illegal woodcutting/selective logging (f)Informal settlements

(b) Conversion of ecosystem land use for crop cultivation (g) Bush fires

(c) Land development

(d) Overgrazing

(e) Illegal sand mining

(h) Illegal waste disposal

(i) Others (specify)

15. In your own perception, what are the reasons for these anthropogenic influences? (Tick as many as applicable)

(a) agriculture

(b) urban expansion

c) Poverty

(d) Weak implementation of conservation policies

(e) Ignorance

(f) Others (specify)

16. As an individual, have you been able to manage or adapt to the environmental problems in your location?

a. Yes

(b) No

SECTION D: ECOSYSTEM GOODS AND SERVICES

17. What are the major ecosystem services provided by the study area? (Tick as many as possible)

(a) PROVISIONING:

Timber	Fuelwood	Pines	Genetic Resources
Medicinal/Cosmetic Plants	Livestock	Fiber Crops	Tree Plantations

Food

(b) CULTURAL

Recreational	Tourism/Ecotourism	Landscape beauty	Education
Scientific research	Traditional knowledge	Cultural heritage	Religious

(c) REGULATING

Erosion control	Hydrological regulation	Climate regulation	Soil purification
Water purification	Waste treatment	Flood buffering	Pest prevention
Air Quality	Habitat maintenance	Carbon sequestration	Coast stabilization
Nursery			

18. Which ecosystem goods and services do you know that are no longer available, or diminished in this area and state why?

SECTION E: URBAN EXPANSION AND CONSERVATION OF COASTAL VEGETATION RESOURCES.

19. In your opinion, what are the reasons for urban expansion: Tick as many as applicable?

(a) Population growth (b) Need for development

(c) Agriculture (Food security) (d) Others

20. What are the impacts of urban expansion? (Tick as many as appropriate)

Pollution	Environmental degradation
Ecosystem biodiversity loss	Infrastructural development
Global warming	Others (Specify)

21. Do you consider the coastal vegetation areas as empty spaces for urban development?

(a) Yes (b) No

22. On a scale of 1 to 10, what impact does urban expansion have on the conservation of coastal vegetation? (1= adversely poor impact; 10= excellently positive impact), please provide your score in the box below:

23. Do you think that coastal vegetation resources should be conserved so that they don't cause long term depletion or affect the diversity of the ecosystem?

(a) Yes (b) No

24. In your opinion, what strategies have been adopted to contain urban expansion and conserve coastal vegetation (Tick as many as appropriate)

(a) Control population growth

(b) Limit urban expansion

(c) Implement coastal ecosystem conservation laws

25. What are the environmental challenges of coastal vegetation in the study area? Tick as many applicable options.

Brackish (Salty) Water

Soil Erosion

conversion of costal vegetation land to other land uses

Steep Slopes

Dusty Winds

Thank you.

University of Fort Hare

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