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Assessment of the impact of land-use management and biodiversity conservation within and adjacent to the Magalies mountain ridge, in Mamelodi (Tshwane), South Africa.

By

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Declaration

I, the undersigned hereby declare that this dissertation entitled “Assessment of the impact of land-use management and biodiversity conservation within and adjacent to the Magalies mountain ridge, in Mamelodi (Tshwane)”, South Africa is my own work, and all sources I have used or quoted have been indicated or acknowledged by means of complete references.

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Nevhufumba Lufuno Date

Abstract

Intensive land-use changes and management can serve as indicators for major impacts on biodiversity, especially when those changes show the loss of natural habitat due to urban sprawl, cultivation, mining, logging, and trawling. Biodiversity is essential for sustainable development and human well-being. The need for biodiversity and land-use management to satisfy human needs while sustaining the earth`s life support systems entails that it is essential to intensify natural resource management for sustainable development and human well-being. Major threats to biodiversity decline are habitat destruction, currently ranked as the primary cause of biodiversity decline, degradation, and fragmentation. This study investigated the impact of land-use management management and biodiversity conservation within and adjacent to the Magalies mountain ridge in Mamelodi (Tshwane), South Africa. A questionnaire survey was administered to 40 respondents so as to understand their perception of the importance of biodiversity, biodiversity conservation, and how the study site was beneficial in terms of resource use and non-consumptive uses. Overall responses indicated that respondents were aware of the importance to their development and livelihoods of land use and biodiversity. Given to the importance of biodiversity, it is critical in general to practice sustainable land management and conserve and ensure sustainable use and management of the resources. Results of the questionnaire survey indicated that the site was viewed as valuable to the community in terms of resources (fruits, medicines, firewood, grass) and non-consumptive uses (cultural, religious, sporting, livestock grazing, hiking, educational, bird sanctuary). At the study site, a plot selected from a 100 m transect was divided into 16 quadrants of 10m x 10m. A total of 538 individual stems of 6 tree species were recorded. Species richness, species diversity, and species index were determined in this plot. *Ochna pulchra* was found to have the highest frequency (86.8), density (29.1) and abundance (31), while *Jacaranda mimosifolia* and *Englerophytum magalismontanum* had the lowest frequency (0.2), density (0.1) and abundance (1). The most dominant stem class distribution was between 10-15cm: which indicated that the sample plot had a young and vibrant population that was managed well. This study was significant because it showed that sustainable land use contributed to biodiversity conservation which offered multiple benefits to the communities.

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The writing of this dissertation has been one of the most significant academic challenges I have ever faced. My first attempt for the studies in this field was made in 2014 and, from that year onwards, I took a break from my studies until I re-enrolled in 2019. The study was successful thanks to the guidance, patience, and support of my supervisor, Prof, Emma Archer, and my co-supervisor, Prof, Paxie Chirwa.

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Dedications

I would like to dedicate this dissertation to myself. I really worked hard for this academic achievement.

TABLE OF CONTENTS

LIST OF FIGURES 5

LIST OF TABLES 6

ACRONYMS

AIP	Alien Invasive Species
CARA	Conservation of Agricultural Resources Act
CBD	Convention on Biological Diversity
CSIR	Council for Scientific and Industrial Research
DACE	Department of Agriculture, Conservation and Environment
DBH	Diameter at Breast Height
DEAT	Department of Environment and Tourism
DNA	Deoxyribonucleic acid
EC	European Commission
ECA	Environmental Conservation Act
ELD	Economics of Land Degradation
ES	Ecosystem Services
EU	European Union
FAO	Food and Agriculture Organisation
GDARD	Gauteng Department of Agriculture and Rural Development
GG	Government Gazette
GN	Government Notices
GPS	Global Positioning Systems
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems
IPCC	Intergovernmental Panel on Climate Change
LADA	Land Degradation Assessment in Drylands
MA	Millennium Assessment

MBR	Magaliesberg Biosphere Reserve
MEA	Millennium Ecosystem Assessment
NEMA	National Environmental Management Act
NEMBA	National Environmental Management Biodiversity Act
NEMPA	National Environmental Management Protected Act
PES	Payment of Ecosystem Services
PCC	Pretoria City Council
SA	South Africa
SACN	South Africa City Network
SADAC	South African Development Community
SAHO	South African Health online
SAIRR	South African Institute of Race Relations
SCBD	Secretariat of the Convention on Biological Diversity
SDGs	Sustainable Development Goals
SLM	Sustainable Land Management
UNCCD	United Convention to Combat Desertification
UNEP	United Nations Environmental Programme
UN	United Nations
UNESCO	United Nations Educational, Scientific And Cultural Organisations
WCED	World Commission on Environment and Development
WWF	World Wild Fund

CHAPTER 1

1.1. INTRODUCTION

Land-use management and biodiversity conservation have received much attention from researchers due to the impact of land use on biodiversity. Land management involves land transformation and land-use changes, and these changes are regarded as the key drivers of biodiversity loss at the local, regional, and global levels(United Nations (UN), 2012). Human modifications on land for various human uses, including farmlands, grazing lands, human settlements, and urban settlements and urban centres have drastically transformed land cover at the expense of natural vegetation.

Land alteration is causing a major impact on global biodiversity (Newbold *et al*.2015), functioning and stability of Earth`s ecosystems (Steffen *et al*.2015), and the provisioning of ecosystems essential for peoples` livelihoods (Kennedy *et al*.2018). Results of long-term studies by various researchers demonstrate the linkages between land-use change, biodiversity loss, and land degradation (Maitima *et al*.2009).

Trade-offs often arise because of bundles of ecosystem services supplied by means of alternative land uses (Smith *et al*. 2013; King *et al*. 2015). For example, food production may increase when natural forest is converted to annual cropping or grazing systems, but at the expense of several other services such as water purification, carbon sequestration, and habitat quality for biodiversity. After major land- use changes, converted or promoted cultural values associated with land use may be favoured or disfavoured. A tough quantification or estimate of various services supplied by natural and transformed ecosystem is essential to manage the trade-offs centred on alternative land use scenarios (Deng *et al*.2016; Verburg *et al*. 2015).

In view of the high demand for variety of services offered by ecosystems, integrative approaches are needed to better safeguard and benefit from them. Furthermore, a better understanding is required as to the supply needs, and management of urban ecosystem services in an area such as Mothong and the adjacent site where land use and biodiversity conservation are practiced. However, this does not necessarily mean that local and indigenous knowledge about the area should not be considered. Ecosystem service science requires a comprehensive framework that recognises social, indigenous, and cultural values of urban ecosystems equally with monetary values in decision-making processes. Local knowledge and practices could be mobilised in multiple ways through, for example, citizen science initiatives, and thus could support the formal governance and management of urban ecosystem services (Elmqvist *et al*. 2013)

To understand how changes in the land system influence the functioning of the entire socio-ecological systems and the trade-offs represented by these changes, it is essential to recognise the drivers, state, trends, and impacts of different land systems on social and natural processes (Verburg *et al*. 2015). Although extensive academic research has explored the relationship between land-use management and biodiversity loss, limited research has focused on land use and biodiversity conservation within peri-urban areas.

This study aims to understand the relationship between land use and biodiversity, by considering an example for better practice in urban biodiversity, namely the example of an individual who is practicing sustainable land use and conserving biodiversity within Mothong and the adjacent area and supported by the community when it comes to conservation efforts in view of multiple benefits derived from the site.

The findings of this research could assist practitioners around considering trade-offs more comprehensively in relation to alternative land- management strategies and allocation of resources used so as to inform the public and policy debate around which development of land is most desirable.

1.2. Problem statement and motivation of the study

Research on land use and biodiversity has grown significantly in recent years, highlighting the links between changes in land use and biodiversity loss. Few studies have however considered issues of land management and biodiversity conservation in the same area. The relationship between land use and biodiversity is critical for understanding the links between people and their environment (Haines-Young, 2009; Rescia *et al*. 2013). Land-use management is a serious concern given that people drastically modify the environment for various purposes resulting in challenges around conserving biodiversity. People`s dependence on biodiversity and ecosystem services (ESs) is increasing, due to population expansion and economic growth (Cimon-Moron *et al*. 2013; Rafferty, 2019; Kennedy *et al*. 2018).

Magaliesberg Biosphere Reserve (MBR) borders the economic hub of South Africa where population increases and development pressure on the region therefore increase. Rapid urbanisation alters ecological processes and functions by changing the ecosystem (Fu *et al*. 2017; Tolessa *et al*.2017. Urban expansion is often done at the cost of biodiversity and ecosystem services therefore, urbanisation challenges environmental sustainability. (Keeler *et al.* 2019; Lyu *et a*l. 2018). Increasing urbanisation is resulting in increased biodiversity loss, especially in large conurbations such as Tshwane, where the ongoing expansion of townships such as Mamelodi is encroaching towards the Magaliesberg mountain ridge, which is part of Magaliesberg Biosphere Reserve. The pristine area provides ecosystem services to the neighbouring community in the form of grazing as well as providing a source of medicinal plants, fruits, and other plant products. The biodiversity around the area is under enormous pressure due to the increased population of the township.

There is an urgent need to understand people's views on biodiversity, their perceptions of biodiversity change, and their attitudes towards biodiversity management if land use and conservation policies are to be sustainable. This study aims to highlight that proper land-use management can result in biodiversity conservation, which will be beneficial to the community of Mamelodi.

1.3. Research aim

The study aims to assess the impact of land-use management and biodiversity conservation within and adjacent to the Mothong African Heritage site within the Magaliesberg mountain area.

1.4. Research objectives

- To assess the effectiveness of proper land-use management in biodiversity conservation at the study site.
- To assess the importance of the study site in terms of non-consumptive uses.
- To examine the value of resources to the local communities at and near the site.
- To evaluate trade-offs between resource use and conservation.

1.5. Research questions

- What is the impact of land-use management and biodiversity conservation on biodiversity within the study site?
- How do land-use management and biodiversity conservation contribute to indigenous knowledge preservation and the use of medicinal plants?
- What is the importance of the study site in terms of non-consumptive uses?
- Are communities adjacent to the study site benefiting from resource use?

1.6. Outline of the thesis

The thesis consists of six chapters. Chapter 1 is the introduction. Chapter 2 consists of a literature review on land use practices and biodiversity decline, Chapter 3 discusses the research methodology, research design, and data analysis procedures, Chapter 4 presents the results of the study, Chapter 5 discusses the findings of the study, and Chapter 6 provides a conclusion followed by recommendations on further researches and what can be done to improve land management and biodiversity conservation of the area within and adjacent to the Magalies mountain ridge in Pretoria (Tshwane), South Africa.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

A range of studies has focused on the impacts of land use on biodiversity over the past decades. Considering the need to maintain the ecosystem and the benefits derived from ecosystem services, there will be constraints on our choices regarding trade-offs between land management and biodiversity (Fastre *et al*.2020; Grass *et al*.2019). Although the literature covers in detail a wide range of issues on land, land use, and biodiversity, this review will focus on the value of land, sustainable land use, and biodiversity. The goal of this literature review is to understand the relationship between land use and biodiversity conservation and relate it to the focus of the research, which is to examine an example of better practice in urban biodiversity in a key peri-urban area.

2.2. Land

FAO(1995) defines land as " a delineable area of the earth`s terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of near-surface climate, the soil and terrain forms, the surface hydrology(including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers associated groundwater, the plant and animal populations, the human settlement pattern and physical results of past and present human activity(terracing, water shortage or drainage structures, roads, buildings, etc.)."

Land provides humans with the means to live and has provided vital resources since the beginnings of evolution. However, at the start of the 21st century, our lands were no longer able to keep up with the pressures placed on its limited resources. Increasing misuse and demands for its goods are resulting in rapidly intensifying desertification and land degradation globally, an issue of growing importance for all people and at all scales (ELD Initiative, 2015). Ecosystem goods and services are the products of the interaction among components of land, and they form the foundation for sustainable livelihoods, social cohesion, and economic growth. Humans are modifying land in a range of ways, causing significant impact to ecosystems that people all over the world depend on for their material, social, and cultural needs (Plumer, 2019; Steffen *et al*.2015; IPCC, 2019).

Land management for ecosystem services should be linked to the demand for services by potential beneficiaries. Land, as an important natural resource, needs to be managed in a sustainable way to achieve the twin goals of the (World Bank,2016) namely, to end a high rate of poverty and boost shared prosperity. Degraded land tends to become unproductive and the capacity of the soil to produce goods and services becomes less. Because of the high costs of restoring degraded land, new areas for agriculture and grazing are opened to meet the increasing demand (UNCCD& World Bank, 2016).

2.2.1. Land use and land-use change

Land use is characterised by the arrangements, activities, and inputs people undertake in a certain land cover type to produce, change, or maintain it. When defined this way, land

establishes a direct link between land cover and the activities of people in their environment (FAO, 1997a). An example may be the conversion of cropland to grassland. Conversion of natural landscape or changing of management practices on human-dominated lands for human benefits is a land-use activity that ultimately transforms the global land surface. The land-use decision reflects the balances between the supply of ecosystems and multiple demands by stakeholders and land users. Trade-off analysis of ecosystem services can assist around identifying optimal decision points to balance the costs and benefits of the diverse human uses of ecosystems (Yahdjian *et al*.2015; Deng *et al.*2016). It is estimated that the human footprint has affected 83% of the global terrestrial land surface and has degraded about 60% of the ecosystem services in the past 50 years (UN, 2012).

2.2.1.1. Categories of land-use change

Land-use change can be catergorised in terms of direct and indirect forms, where land-use change where direct land-use change refers to a process where a piece of land is converted from one specific use to another use. An example is a deforested forestry land replaced by new cropland. Indirect land-use change occurs when there is a straight change in land use in one location and there is a resultant change in another location. The mechanism behind this shift in land use from one location to another is the influence of agricultural markets on regional or global land use. In practice, this means that land-use change is exported to locations where there is land with the potential to be converted into new agricultural land. As a result, a change in land use in one location (such as Europe) can potentially lead (indirectly) to changes in land use on the other side of the world, often in lower-income countries where the ecological cost of land conversion is often high because of the richness and unique character of biodiversity on the land being converted (Lambin *et al*. 2001).

Land use is practiced in both urban and rural areas. Urban land use includes land utilised for residential, commercial, industrial, institutional, transportation, communicative, and general utilities, whereas lands not resorting under the urban classification, including agricultural land, farmland, cropland, rangeland, and forestland, belong to rural land use (Balasubramanian, 2015). These land uses tend to degrade the ecosystem and services that support humans, and this presents a dilemma that requires careful thought when it comes to using land and resources (Foley *et al.* 2005).

2.3. Sustainable land management

Sustainable land management (SLM) is defined as “the stewardship and use of land resources, including soils, water, animals and plants, to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions” (World Bank, 2006; ELD Initiative, 2015, WWF Living Planet Report, 2018). The definition of sustainable development according to the Brundtland report (WCED, 1987) offers a starting point for discussing SLM. Sustainable development is a development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs WCED, (1997).

The objective of SLM is to harmonise the complementary goals of providing environmental, economic, and social opportunities for the benefit of present and future generations while maintaining and enhancing the quality of land, water, and air resources (Smyth & Dumanski,1993). SLM is a key element in Agenda 21`s goal of sustainable development (World Bank, 2008). In a further source, the World Bank(1997) indicates that they regard sustainable agricultural development, conservation of natural resources, and promotion of SLM as key objectives of rural investment programs.

2.4. Land degradation

Land degradation is the persistent reduction of the capacity of the land to support both biodiversity and human needs. It takes many forms, including the loss of soil, or soil health in croplands, loss of habitat and hydrological function in urban areas, deforestation, or over-logging in forests, overgrazing and shrub encroachment in rangelands, and drainage and eutrophication in wetlands (WWF, The Living Planet Report, 2018; LADA project, 2013).

Information on the causes of land degradation is critical for policymakers around developing relevant response options, techniques, policies, financial incentives, and behaviour changes. Land degradation tends to affect the same areas transformed into agricultural systems and includes mainly forests, rangelands, and wetlands, which are central to human survival (IPBES, 2018).

2.4.1. Land degradation in the global context

As a global challenge, land degradation affects everybody around food insecurity and higher prices, through climate change and environmental hazards, and in terms of the loss of biodiversity and ecosystem services (Davies, 2016). As a solution, an integrated geographical approach is needed: otherwise, some of the problems may be ignored and others created unintentionally (Conacher, 2009). Land degradation has been acknowledged by world leaders as a global problem to be taken seriously in three ways: its extent and the proportion of the global population affected, international environmental policy responses, and its interrelation with other global environmental issues such as biodiversity (Gisladottir & Stocking, 2005).

2.4.2. Land degradation in South Africa

Land and water resources in South Africa are under tremendous threat due to soil erosion. The clearing of vegetation, soil tillage, or overgrazing are human activities accelerating soil erosion. It is intensified because of poor farming practices as well as the shift towards agricultural expansion. The process of soil formation is regarded as a relatively slow process and, as a result, it is a non-renewable and a limited resource. Continued erosion results in irreversible loss of soil over time, reducing the ecological functions such as biomass production and hydrological functions such as filtering, infiltration, and holding capacity of the soil (Le Roux & Smith, 2014).

Soil erosion results in the loss of fertile topsoil and reduction of soil productivity. Because of soil erosion, serious off-site impacts related to increased mobilisation of sediment are

inflicted on rivers, causing siltation and pollution of South Africa's water scarce resource. Pollution and sedimentation of water bodies due to suspended sediment concentrations in streams are threatening scarce water resources in South Africa. One of the major challenges faced by the Department of Water Affairs of South Africa is the mobilisation of eroded soil and its delivery to rivers and dams (Le Roux & Smith, 2014).

The history of land ownership, land tenure, and labour dynamics determine the pattern of land degradation in South Africa (Hoffman & Ashwell, 2001). The main types of land degradation are loss of cover, change in species composition, bush encroachment, alien plant invasion, and deforestation (Hoffman & Ashwell, 2001). In South Africa, there is a positive correlation between land degradation and population density with a high-degraded area found within former homelands (Bai *et al*. 2008). The reliance of rural communities on natural resources, rural poverty, poor infrastructure, and lack of service delivery are factors that contribute to the high rate of degradation in the former homelands. Land management as well as fluctuations in weather conditions can assist in determining the rate of degradation, which tends to cause disappearance in areas suitable for agriculture and forestry and disrupt the equilibrium of the ecosystems (Schiller, 2019). A study conducted on the relationship between vegetation conditions and local grazing management systems across the communal villages of the central Keiskamma catchment, Eastern Cape Province, revealed a drastic reduction in fair vegetation, and increase in extremely degraded vegetation and bare/eroded surfaces, particularly in villages with ineffective rangeland management practices (Kakembo & Ndou, 2019).

2.5. Biodiversity

The high rate of biodiversity decline and its recognition in terms of supporting human life has led to the creation of several international initiatives to reconcile human development with conservation, the maintenance of human impacts within "safe ecological limits" (Target 4: SCBD,2010 Secretariat of the Convention on Biological Diversity, 2010)(SCBD,2010), a legally binding global treaty with the objective of the conservation and the sustainable use of its consumption(Niesenbaum, 2019), the 2020 Aichi Biodiversity Target for the establishment of the protection of 17% of global terrestrial land (Target11), and the restoration of 15% of degraded ecosystems (Target 15). The UN's 2030 Sustainable Development Goals (SDGs) calls for the protection, restoration, and sustainable use of ecosystems, and the halting and reversal of land degradation and biodiversity loss Goal 15(Cowie *et al*. 2018). One of the main arguments in biodiversity conservation is that its maintenance is crucial for ecosystem function and services that link biodiversity, sustainability, and ecosystems (Niesenbaum, 2019).

The human population seems, in part, to be unaware of the damage they inflict on the environment, biodiversity included, although awareness is growing. People need to change the way in which they utilise natural resources to avoid ongoing biodiversity degradation (Mooney & Pelchar, 2009).

2.5.1. Biodiversity defined

As indicated, biodiversity is a scientific term describing the variety of life on Earth. It is about sheer numbers of different species, genetic variation among and within species, and the extent and variety of natural habitats and ecosystems (Roe *et al*.2019; Biologydictionary.net, 2019; IPBES, 2019; Pim, 2019.) A measure of the diversity of species is species richness, which is the count of species in an area. Biodiversity is now declining faster than at any time in human history due to population increase (FAO, 2019).

2.5.2. Three levels of biodiversity

There are three different levels of biodiversity, which together form a set of data that can describe the biodiversity of an area of land, freshwater, or sea. The three are genetic diversity, species diversity, and ecosystem diversity (Biology dictionary. net, 2019).

2.5.2.1. Genetic diversity

This encompasses to the differences in the genetic make-up of a distinct species and the genetic variations within a single species. People are of the same species but have genetic variations that make us diverse. Plants of the same species can diversify to be able to live in an alternative habitat (Biology dictionary. net, 2019).

2.5.2.2. Species diversity

Species diversity is a measurement of biological diversity to be found in a specific ecological community. It represents the species richness or number of species found in such a community in terms of their abundance (or number of individuals per species) and distribution or evenness. When it comes to only the number of different species within an ecosystem, we then speak of species richness. Species richness only concerns the number of different species in an ecosystem, not their distribution (Biology dictionary. net, 2019).

2.5.2.3. Ecosystem diversity

The major habitat types from which all other smaller systems derive are called terrestrial, marine, and aquatic ecosystems. The three examples of ecosystem diversity contain further examples as subgroups. In a particular area of the planet, large or small, the number of ecosystems that can be found with it defines its ecosystem diversity (Biology dictionary. net, 2019).

2.5.3. Importance of biodiversity to human development and well-being.

Morton & Hill 2014 describe five core (and interacting) values that humans place on biodiversity.

2.5.3.1. Economic support

Biodiversity provides humans with raw materials for consumption and production. Many livelihoods, such as those of farmers, fishers, and timber workers, are dependent on biodiversity.

2.5.3.2. Ecological life support

Biodiversity provides functioning ecosystems that supply oxygen, clean air, and water, the pollination of plants, pest control, wastewater treatment, and many ecosystem services.

2.5.3.3. Recreational support

Many recreational pursuits rely on our unique biodiversity, such as birdwatching, hiking, camping, and fishing. Our tourism industry also depends on biodiversity.

2.5.3.4. Cultural support

The Australian cultures are closely connected to biodiversity through the expression of identity, through spirituality, and through aesthetic appreciation. Indigenous Australians have strong connections and obligations to biodiversity arising from spiritual beliefs about animals and plants.

2.5.3.5. Scientific support

Biodiversity represents a wealth of systematic ecological data that help us understand the natural world and its origins.

2.5.4. Ecosystems services and human well- being.

Despite the importance of Earth`s ecosystem and the services it provides to human well-being, ecosystems have over the past 50years changed more rapidly and extensively than in any comparable period in human history, largely to meet rapidly growing demands for food (IPBES, 2019; FAO, 2019; Di Marco, 2019).

For the ecosystem to provide benefits to people, the existence of people is important (human capital), and so are their communities (social, capital) and their built environment (built capital) (Figure 2.1). Ecosystem services need to be recognised as a contributor to natural capital for human well-being, which forms only by the interaction with human, social, and built capital (Pecina *et al*. 2018).

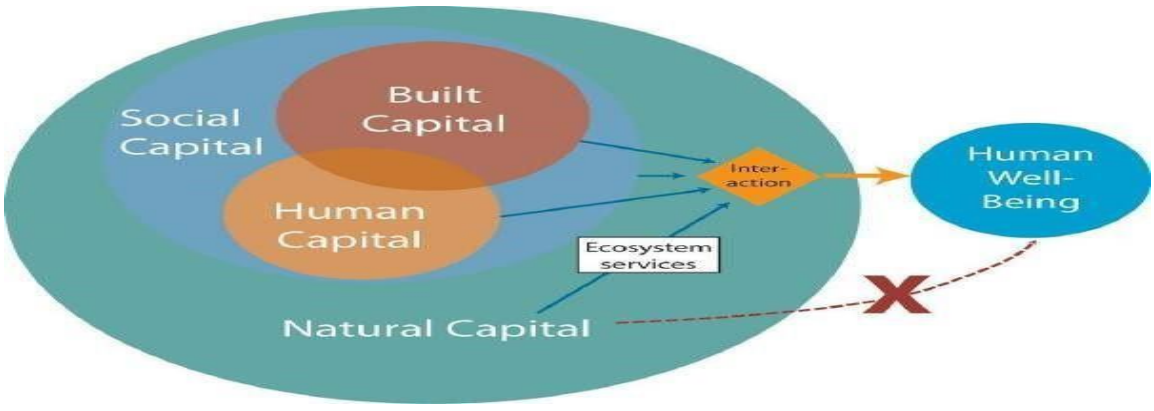

Figure 2.1. Interactions between built, social, human, and natural capital (Costanza *et al*. 2014)

2.5.4.1. The interrelations between biodiversity, ecosystem, and socio-economic system

The interrelation between biodiversity, ecosystems, and socio-economic systems via flows of ecosystem services and drivers of change can be reflected by the conceptual framework for EU and national ecosystem assessment developed by MAES initiative under Action 5 of the EU Biodiversity strategy (Maes *et al*., 2016) [Figure 2.1, Figure 2.3].

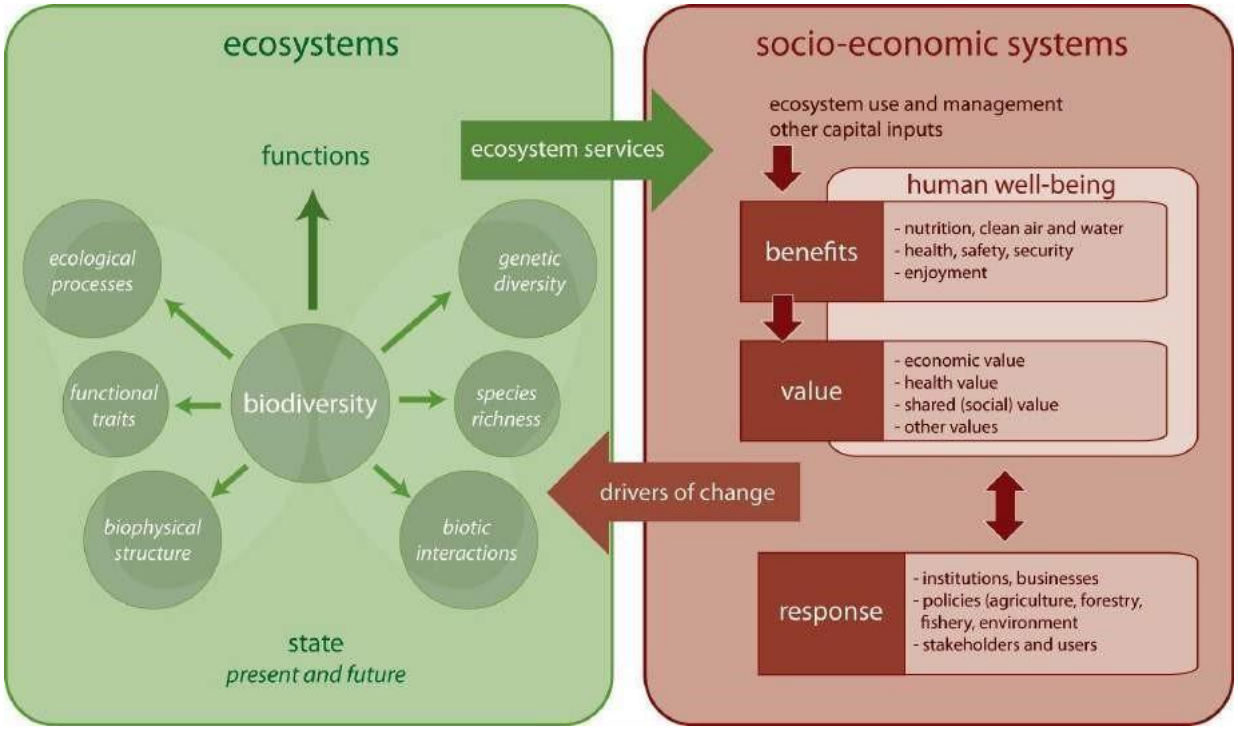

Figure 2.2. The links between ecosystem services and constituents of well-being (Maes *et al*. 2016)

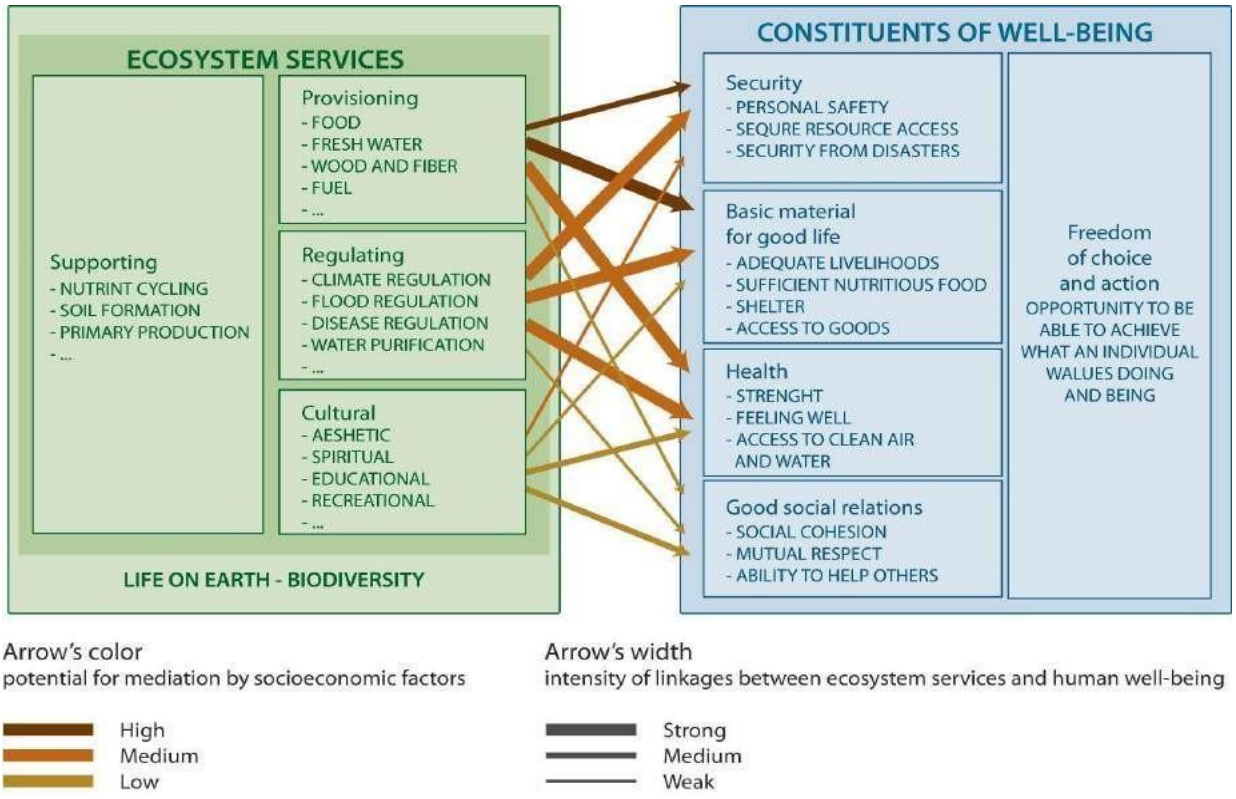

Figure 2.3. Ecosystem and well-being (MA, 2005)

2.5.5. Drivers of biodiversity loss

Biodiversity loss is the decline in the number, genetic variability, variety of species, and the biological communities in each area. The loss in the variety of life can lead to a breakdown in the functioning of the ecosystem where the decline has happened (Rafferty, 2019). Humans have deeply altered the environment, and have modified the territory, exploiting the species directly, changing the biogeochemical cycles, and transferring species from one area to another of the planet (Roe *et al*. 2019; Bastamante *et al*. 2018).

2.5.5.1 Urbanisation and biodiversity loss

Increasing human population and urban sprawl are driving the fast transformation of natural and rural environments into urban ecosystems worldwide (McDonald *et al*. 2020; Onandia, 2019). Over the past six decades, 25% of the global population has moved from rural into urban settlements and this trend is expected to continue (UN, 2014). Urbanisation is a powerful driver of change in biodiversity patterns, associated with filtering species according to their pre-adaptation to urban environments. Urbanisation has been linked to a loss of biodiversity, ecological homogenisation, and changes in community composition, including a higher proportion of alien species pre-adapted to novel habitats and species compositions that cannot be found in near-natural environments (Onandia,2019).

In many regions, the share of population living in cities, as well as the number and size of cities, will continue to grow, driven by a combination of factors, including a surplus of births

over deaths in urban areas, migration from rural to urban areas and from abroad (Lerch, 2017), and the urbanisation of formerly rural areas (Cobbinah *et al*.2014). The impact of urban land-use expansion concomitant with changing consumption patterns leads to an increased ecological footprint (demand for food, water, and other goods and services) due to associated land-use changes. Degradation of such an ecosystem and its services has the potential to affect the well-being of both urban and rural populations that rely on them (CBD, 2018).

The population of South Africa is increasingly urbanised in accordance with the standard of the world. Two-thirds of the population in South Africa live in urban areas and there has been an overall increase in this population from 52% in 1990 to 62% in 2011(SAIRR, 2011). The increase was due to the abolishment of restrictions on the movement of people from rural areas to urban areas after 1994. Gauteng hosts the largest population in South Africa. Continued population growth puts pressure on the natural environment, including biodiversity (CSIR, 2008).

2.5.5.2. Intensification of agriculture

Agriculture destroys biodiversity by converting natural habitats to intensively managed ones and by releasing pollutants, including greenhouse gases (Dudley & Alexander, 2017). Lately, the increase in agriculture also incorporated genetically modified crops, which offered new opportunities to increase yields in the coming decades, but there has been a risk of pesticides and fertilizers that pollute the environment, and soils have been degraded (Hails, 2002). Remaining natural habitats are damaged due to agricultural expansion that results in major extinction of fragmented, small, and isolated populations (Benton *et al*. 2003). Species loss is a result of the extinction of both deterministic agricultural expansion and stochastic processes engendered by habitat fragmentation. Residence of the informal settlements carried out small-scale agriculture to supplement their living resulting in large fractions of grassland and cultivated land becoming built-up areas (Ololade *et al*. 2008).

2.5.5.3. Fire

The importance of fire is that it plays a critical role in maintaining the health of certain ecosystems but, because of changes in climate and human use (and misuse) of fires, it is now a threat to many forests and their biodiversity. Humans have used fire for thousands of years as a land management tool. However, in the latter part of the twentieth century, changes in the human-fire dynamic and an increase in El Niño frequency have led to a situation where fires are now a major threat to many forests and their biodiversity (SADAC learner guide, 2019). On the global scale, fire is a significant source of emitted carbon, contributing to global warming, which could lead to biodiversity change. Fire strongly promotes fire-tolerant species, which replace the species potentially growing in an undisturbed environment. Fire, whether natural or human-made, can disturb and strongly change the structures and functional processes of forest ecosystems (Greentumble, 2016).

2.5.5.4. Overharvesting and its effects

Overharvesting, also called overexploitation, refers to harvesting a renewable resource to the point of diminishing returns. Overharvesting is a threat to biodiversity as it degrades the ecosystem and eliminates species of plants, animals, and other organisms. Until recently, human populations harvested resources in limited quantities ensuring resource sustainability. Presently, new methods of harvesting and capturing contribute to overharvesting and overexploitation. A range of factors leads to overharvesting, including the human population, expanding markets, increased demand, and improved access and techniques for capture. Throughout South Africa, including the area within the Magaliesberg Biosphere Reserve's rural communities, harvest woody plants for fuel, furniture, building materials, food, medicine. Plants and animals are also harvested by non-rural communities for commercial use in medicines, as cultural artifacts, timber, ornamental plants, and they harvest live animals for post markets. These forms of overexploitation can have severe impacts on biodiversity (DACE, 2008).

Overharvesting can lead to resource destruction including extinction at the population level and extinction of the whole species. It threatens not only the resource being harvested but can also directly impact humans – for example, by decreasing the biodiversity necessary for medicinal resources. A significant proportion of drugs and medicines are natural products that are derived, directly or indirectly, from biological sources. However unregulated, and inappropriate harvesting could lead to overexploitation, ecosystem degradation, and loss of biodiversity; further, it could negatively influence the rights of the communities and states from which the resources are taken (DACE, 2008).

2.5.5.5. Alien invasive species

An invasive species is one that is not native to a specific location (an introduced species),and that tends to spread to a degree believed to cause damage to the environment, human economy, or human health(Ehrenfeld, 2010). Invasive species may arrive in new areas through natural migration or human introduction (Rafferty, 2019). This can occur intentionally as with the introduction of crop or livestock species, or accidentally, such as when species are introduced through ballast water or stowing away in cargo containers (Mooney & Pejchar, 2009; SCBD, 2009). Alien invasive plants (AIPs) are the major drivers of biodiversity loss in the terrestrial environment and across the globe, and the estimation is that they cost economies of the world hundreds of billions of dollars each year. They act adversely upon biodiversity, including the decline or elimination of native species - through competition, predation, or transmission of pathogens - and the disruption of local ecosystems and ecosystem functions. Species are often introduced deliberately: though, for example in the case of fish farming, pet trade, horticulture, and biocontrol- they may be introduced unintentionally by means of land and water transportation, travel, and scientific research(SCBD, 2010; State of the World Plants,2017). Woody plants that are now problematic such as pine and eucalyptus, were introduced to be harvested for poles used during construction, mining and infrastructure, black wattle was introduced for leather tanning, whereas syringa and jacaranda were introduced as ornaments (DEAT, 2014).

Figure 2.4. Phases of invasion (Crookes & Soule,1999)

i. Introduction

The introduction of the species coming from another place means that they must survive during and after the journey. However, almost all invasive plants spread as seeds, which do not require special care while being transported.

ii. Establishment and reproduction

The survivors need to persist and reproduce successfully (that is, there usually needs to be more than one individual) until they establish a self-sustaining population.

iii. Spreading

In certain cases, established populations will multiply rapidly and spread across the landscape. This is the explosion phase and may only happen after a considerable lag phase.

iv. The lag phase

Some species show no lag phase and will begin to spread rapidly and uncontrollably as soon as they establish. On the other hand, many AIPs have a lag phase during which they occur at low densities and their impacts are not noticeable. The duration of this lag phase will vary depending on the species and circumstances and may involve only a few months; or it may take as long as centuries. Once the population starts increasing (explosion phase), the impacts will rapidly become apparent. Following the explosion phase, the growth levels out, and as the population capacity of the environment growth levels out, and as the population reaches the carrying capacity of the environment (Crookes &Soule, 1999).

South Africa is regarded to be a water-scarce country and it is estimated that about 1.44 billion m^3 of water is lost to AIPs, an amount of water enough to provide 3.38 billion households with four inhabitants for a year and to irrigate 120 000 hectares of croplands. Two processes occurring around AIPs are expansion and densification, where existing stands of IAPs spread by dispersal, particularly along seed dispersal vectors such as paths, roads, and seasonal and perennial watercourses, which is then followed by densification of new colonies (WWF, 2016).

2.6. Biodiversity conservation

Biodiversity conservation refers to the management of human use of biodiversity to get the greatest sustainable benefit to present and future generations: thus, conservation of biodiversity embraces the protection, maintenance, sustainable utilisation, restoration, and enhancement of biodiversity (Balakrishnan & Kasso, 2013).Food plant and animal species have been collected, used, domesticated, and improved through traditional

systems of selection over many generations however, today the evidence is increasingly pointing out a significant decline in biodiversity by numerous, varied and interacting drivers (Young *et al*. 2007).

2.6.1 Two groups of complementary conservation techniques

2.6.1.1.The in-situ group is defined as conservation of ecosystems and natural habitats, the maintenance of a viable population of the species in their natural surroundings and, in the case of the cultivated species, in the surroundings where they have developed their distinctive properties. The major aim of this type of conservation is to preserve the natural areas of the organisms and maintain their number. The method is beneficial for the conservation of wild organisms and for animals to breed in the natural habitat itself. In situ conservation can be done in farmer's fields, in pasturelands, and protected areas. This type of conservation is divided into three further types, namely protected area conservation, home garden conservation, and on-farm conservation. In situ conservation is a good method to protect an endangered plant or animal species in its natural area, either by safeguarding the habitat itself or by protecting the species from predators (Fotedar, 2018).

In situ conservation has certain limitations (Leus, 2011), including difficult access to breeders that require the application of its complementary techniques, like some of the natural habitats or wild habitats are very risky when compared to a relatively safe captive environment.

2.6.1.2. Ex-situ conservation

Ex-situ conservation is a technique for conserving biological diversity outside natural habitats, targeting all levels of biodiversity, including genetic species and ecosystems. In this method, sampling, shifting, storage, and preservation of target taxa are carried out outside the natural habitat of the organisms. The method is more static and is quite suitable for the conservation of several crops and their wild varieties. Various methods are used to this end , including vitro storage, DNA storage, seed banks, and pollen storage. Types of ex-situ conservation include zoos, captive breeding, aquaria, botanical gardens, and gene banks (Fotedar, 2018).

2.6.2. Protected areas

A protected area is a geographical space, recognised, dedicated, and managed through legal or other effective means so as to achieve the long-term conservation of nature, including associated ecosystem services and cultural values (Dudley, 2008).There are six categories of such areas. The first category, strict protected area is further divided into two subcategories, namely strict nature reserves and wilderness areas. The strict nature reserve is designated for the conservation of biodiversity and geological and geomorphological features. In this reserve, visitation, use, and impacts of humans are controlled and limited to ensure that conservation values are protected. Meanwhile, the wilderness area normally deals with large unmodified or slightly modified areas that retain

their natural character and influence. To ensure that natural conditions are protected and preserved, the areas are without permanent or significant human habitation.

The second category is the national park, which consists of large and natural areas that protect large-scale ecological processes with characteristic species and ecosystems. The national park also provides scientific, spiritual, educational, recreational, and visitor opportunities. The third category is identified as a natural monument or feature. These areas are set aside for the protection of specific natural monuments. These include landforms, seamounts, marine caverns, and ancient groves: consisting of some geological feature such as a cave and a living feature such as an ancient grove (Suratman, 2018).

The fourth category is habitat or species areas in which the management is prioritised to protect particular species or habitat. Active and regular interventions are required to meet the needs of particular species and habitats. In the fifth category, that is the protected landscape and seascape, the interaction of people and nature over time may produce the distinct character of the protected area, which includes significant ecological, biological, cultural, and scenic values. Safeguarding the integrity of this interaction is crucial to ensure the protection and sustainability of the area. The final is a protected areas where sustainable use of natural resources occurs. This involves an integration of ecosystem conservation, cultural values, and natural resource management, which further involves large and natural area conditions. One of the aims for this category is the use of natural resources compatible with nature conservation (Suratman, 2018).

2.6.3. Market tools: payment of ecosystem services

The payment of ecosystem services(PES) is used to provide incentives and financing for biodiversity conservation. PES is a way of internalising the positive externalities associated with a given ecosystem or a specific resource (Pagiola *et al.*2004). PES is a voluntary transaction where a well-defined ecosystem service or a land-use likely to secure that service is bought by a minimum of one ecosystem service buyer from a minimum of one ecosystem service provider, if and only if the ecosystem secures ecosystem service provision conditionally (Wunder, 2005).An example may be payments made by a carbon offset buyer towards either reforestation or the conversion of existing forests and represent a form of PES in which the beneficiary is the person buying the carbon offset and the provider is the person planting trees or doing conservation programs.

2.6.4. Offsets

Biodiversity offsets are conservation measures designed to remedy the residual negative impacts of development on biodiversity and ecological infrastructure, once the first three groups of measures in the mitigation sequence have been adequately and explicitly considered: that is to avoid, minimizes and rehabilitate/restore impacts. Offsets are becoming internationally accepted tool, that, can be used to ensure that development is ecologically sustainable by enhancing the conservation and sustainable use of priority ecosystems and fragile

biodiversity-rich areas not under formal protection (SA,2017). Offsets are considered voluntary or mandatory arrangements in which firms, industries, or national governments offset unavoidable environmental damage in one location with investments in environmental conservation in another location (Nkonya *et al*. 2012). The Wetland Mitigation Banking operating in the United States is an advanced model of an offset scheme (Swallow, 2007). A transferable development rights system is a cap-and-trade instrument. by which forest holders (those who have at least an effective right of exclusion on the forest they use) can sell non-used development rights to other forest holders who need to clear the forest beyond the threshold cap. There is a need to set a maximum deforestation cap by zone and a stringently controlled mechanism. A mitigation banking institution can be set to regulate the exchange and reduce transaction costs.

2.6.5. Integrating landscape with biodiversity conservation

By the year 2100, the impact of change by land use on biodiversity will likely be the most significant driver of biodiversity change at a global scale (Chapin *et al*. 2000). Traditional rural landscapes such as open savannah-like woodlands used as pastures or extensive livestock farming in mountains are important when it comes to conserving biodiversity (Rescia *et al*.2010). Integrated landscape management in which conservation and production units are managed jointly for long-term sustainability to preserve biodiversity is necessary(Green *et al*. 2005).

2.6.6. Research and technology

Researchers such as biologists, ecologists, and social scientists play various roles in conservation (Evans,2021). They identify species and their habitats, locate areas of high ecological value, pinpoint threats, and propose innovative strategies and solutions to challenges found. Researchers use various methods such as field surveys, observations and experiments, and technologies including remote sensing devices, data analyses, software, and laboratory tests to these ends. Research results are very important for biodiversity conservation. They can be woven into community development programmes. Local communities can be important contributors to biodiversity conservation research and should be involved in all steps of the research and conservation processes (Sandbrook *et al*. 2019). Conservation and development activists, journalists, government decision-makers, and even businesses use research results. The creation and application of technologies are important benefits of biodiversity conservation research (SCBD,2020). Technologies are invented, selected, evaluated, tested, and applied to solve problems. Technologies can be transferred from rich countries to poor ones and vice versa and this process can be essential to community development. Before using any technology, however, it is critical to have a clear understanding of its characteristics so that the intervention does not harm local livelihoods, traditions, cultures, or the environment (Bilgi &Hay-Edie, 2016).

2.7. Indigenous knowledge in biodiversity conservation

According to UNCED (1992), indigenous knowledge is defined as “the holistic, traditional scientific knowledge of people`s land, natural resources and environmental development over many generations as a result of their interrelationship with the natural environment towards cultural, social, economic and physical well-being of the indigenous people”. Regrettably, modern management theories and practices do not recognise indigenous knowledge (UNCED,1992).

Indigenous knowledge is the foundation for making decisions at the community level in areas regarding food security, the health of both humans and animals, education, and natural resource management. Despite the contribution and value of indigenous knowledge in biodiversity conservation, the knowledge is declassed or even not remembered and is not taken into consideration among rural communities; and is slowly disappearing (AyaDominics & Waswa, 2016). Tradition in local communities includes natural resource conservation conveyed through beliefs and practices used in the utilisation and management of these resources. Indigenous resources unfold in management of natural resources unfold when communities interact with the environment, thereby leading to practices around cultural landscape viewed as sacred, such as forests and grooves, and (Eneji *et al*.2012).a variety of ethnic forestry practices

2.7.1. Indigenous knowledge in South Africa

During apartheid in South Africa, alienation, and suppression of indigenous knowledge, occurred and those practicing the knowledge were subjected to mockery (Noyo, 2015). Integrating and celebrating indigenous knowledge in South Africa assists in the formation of research paradigms and mental maps and in enriching the existing one. A new policy in South Africa was developed after the dawn of democracy in1994 (Msimanga & Shizha, 2014).

Scientific literature suggests that, besides the role of scientific knowledge in biodiversity conservation, there is growing interest in the role of indigenous knowledge practices and systems when it comes to ensuring the sustainable utilisation and conservation of biodiversity (Sinthumule &Mashau, 2019). Our biodiversity is under threat because traditional conservation ethics gave way to modern socio-economic forces. The government of South Africa developed an indigenous policy, incorporated in all measures, and policies can assist around sustainable use and conservation of our precious resources.

2.8. Factors influencing perceptions and attitudes in biodiversity conservation

2.8.1. Superstition

Traditions and taboos are important ways of preventing overharvesting of plant materials (Van Wyk *et al*. 1997). While all members of the society remove/use tree species. totemic plants differ amongst ethnic groups and different clans of the same community. For example, the Vhatavhatsindi tribe of Thengwe in the former Venda homeland in Limpopo, reveres the Mutavhatsindi tree (*Brackenridgea zanguebarica*) Van Wyk *et al.*1980) and it

dominates their praises; it is taboo amongst the tribe to use the tree species for firewood (Ralushai,1997). *Alepidea amalymbica* is collected in winter, thereby reserving the plant for the season when coughs, colds, influenza, and bronchitis are most prevalent. The tradition is important because it ensures the plant is left in the field to set seeds in summer. In a Shangaan taboo, in the former Gazankulu in Limpopo Province, there is a belief that the remaining root system of *Elephantorrhiza elephantina* needs to be covered after a portion has been removed so that the patient treated recovers from the illness. When treating kidney disease, barks are harvested from the eastern and western side of the tree, symbolising the kidneys. The belief is that the bark will cure the kidney problem and this method of harvesting prevents the tree from ring barking (Van Wyk *et al*. 1997).

An experienced inyanga, that is, a herbalist who does not perform rituals that are common to the sangoma," generally seeks the guidance of the ancestral spirit before embarking on a journey to collect and harvest plants for medicinal purposes. Through dreams or prayers, the healer receives guidance on the best time for collecting plants and the location of the plants (Van Wyk *et al.* 1997).

2.8.2. Customs and rituals

Customs and rituals played an important role in conserving sacred forests in Thathe Vondo, which is the ancient burial ground of Tshidzivhe clan. According to tradition, only Makhadzi and the uncircumcised males of the Tshidzivhe clan can enter the forest. Immediately after the chief dies, he is buried at the sacred forest, whereas other members are buried in the royal kraal first and then, after some years, their bones are reburied at the sacred forest. Due to these practices, the forest is highly respected by the community, and this saves the forest from deforestation, hunting, poaching, and the starting of wildfires by community members (Sinthumule& Mashau,2019).

In Venda,rituals (U phasa) are performed in winter (June/July) during which time the Makhadzi of the clan asks for rain, peace, and thanks to the ancestors for a good harvest and protection. Traditional beer (Mahafhe) and snuff (tobacco) are sprinkled on the ground in the forest, as Makhadzi communicates with ancestors; this reinforces the holiness of the forest, contributing to the conservation of the forest (Parrotta *et al*.2016). There is evidence of similar practices in the Chirovza and Daramombe hills of Zimbabwe (Mavhura & Mushura, 2019).

2.8.3. Myth and taboo

It is believed that the spirit of Chief Nethathe appears in the shape and form of a white lion and guards the graves and sacred forest. Those trespassers not belonging to the Tshidzivhe clan are believed to face the risk of harm or attack from the white lion. It is believed a European white man disappeared mysteriously in the forest because he disobeyed the warning and entered the forest, and this myth has protected the forest and continues its protection from destruction (Sikhitha, 1999).

2.9. International biodiversity policy context

The ever- increasing loss of the Earth`s biological wealth due to human actions is a major concern throughout the world. Unless intervention takes place, crucial life- support systems are to be lost through the destruction of important habitat, and livelihoods will be undermined, degradation of natural resources base on which people depend will occur, economic opportunities will be at risk of diminishing as options for developing medicines and food are reduced, and the natural resource base for tourism will be damaged (SA,1997).

2.9.1. Convention on Biological Diversity

The Convention on Biological Diversity and sustainable use of its components came into existence in 1972 at the UN Conference on Human Environment in Stockholm. Conservation of biodiversity was identified by UNEP as a priority area in 1973; hence, there was a need to get the legal mandate for the conservation of world resources. Delegates negotiated for a legally binding instrument to address biological diversity and its loss to enhance fairness and equity in sharing of its benefits, which led to the formation of Convention on Biological Diversity (Mutia, 2009). Opened for signature in 1992 at the United Nations Conference on Environment and Development (UNCED), the convention came into force in December 1993. The convention's objectives were retaining of the biological diversity, sustainable use of its components, and a fair and equitable sharing of its benefits. Even though South Africa signed the treaty in June 1993, it only became binding after the National Assembly and the National Council of Provinces approved it in November 1995, and the country became a member of the convention (Algotsson, 2009; Wynberg, 2002).

2.9.2. Biodiversity policy for South Africa

2.9.2.1. History of biodiversity conservation in South Africa

For many centuries, people of South Africa practiced conservation, and evidence suggests the application of elaborate natural resource management systems by indigenous African people such as the San, Khoi, and Nguni prior to the country`s colonisation. Because of the dependence of traditional African people on natural resources, including wildlife surrounding them, they developed a set of rules and procedures designed to regulate the use of these (SA, 1997; Wynberg, 2002).

Apart from the traditions, beliefs ,and knowledge systems of indigenous peoples living in South Africa, the system known presently began when the Dutch settlers, soon after their arrival in 1652, introduced restrictions on the cutting of trees and hunting of wildlife. The focus changed from species preservation to a more comprehensive approach of habitat and ecosystem conservation and the notion of sustainable development. A statutory body called the Council for the Environment was established in 1980 to advise on policy matters. The recommendations were put on hold in the early 1990s pending the outcome of negotiations, which were to decide on the new constitutional arrangements and allocation of responsibilities to the different levels of government (Muller, 2009).

2.9.2.2. The scope of policy in South Africa

Prior to 1990, environmental protection in South Africa was administrated by uncoordinated and reactive administration through legislation regulating specific environmental media. The government enacted the Environmental Conservation Act (ECA) in 1989 which was South Africa`s framework law until the enacted of National Environmental Management Act in 1998(Van der Linde, 2009).

2.9.2.3. Constitutional context

The adoption of the 1996 constitution resulted in the advancements of environmental protection in South Africa. Of major significance was the inclusion of environmental rights through section 24 of the constitution and inclusion resulted in a more coordinated and integrated approach to environmental protection at the national level.

Supporting all these initiatives is South Africa`s new constitution which provides, within its Bill of Rights that, everyone has the right to

(a) an environment that is not harmful to their health or well-being;

(b have the environment protected for the benefit of present and future generations, through reasonable legislative and other measures that;

(1) prevent pollution and other degradation;

(2) promote conservation;

(3)secure ecological sustainable development and use of natural resources while promoting justifiable economic and social development.

In terms of the constitution, it is the role of the central government to administer international treaties. The responsibility is given to the Department of Environmental Affairs to formulate general policy concerning the conservation and use of biodiversity, the implementation of which is undertaken by different government institutions within central, provincial, and local spheres (Van der Linde, 2009; SA,1997).

2.9.2.4. South African legislations for biodiversity conservation

Table 2.1. South African biodiversity legislations

Legislations	Purpose of the legislations
Post constitutional context National Environmental Management Act107 of 1998(NEMA)	NEMA gives effect to section 24 of the constitution and the National Environmental Management Policy for South Africa. The act contains several instruments to promote and give effect to the principle of co-operative governance and sets a framework for integrated environmental management in all development activities in the country. NEMA has four pillars, namely an attempt to ensure quality in environmental decision making through the National Environmental Principles and through the procedures laid down for improving quality and consistency, to provide for co-operative governance procedures through establishment of the Committee for Environmental Co-ordination and, lastly, the allocation made for civil society participation in environmental governance through, inter alia, the National Environmental Advisory Forum, Environmental management Co-operation Agreements, access to environmental information, and protection of whistle-blowers(Van der Linde, 2009, Swanepoel, 2016).
Listing notices 1 GN 327 2017.	Outline's activities that require environmental Impact assessments (SA,1998).
Regulation 32 of GN 542 published under section 24 of NEMA.	Contains requirements and guidelines for specialist studies
The National Environmental Management Biodiversity Act, Act No 10 0f 2004.	The passing of this act, known as NEMBA was one of the most important steps towards a comprehensive approach to biodiversity conservation. In line with the CBD, the act aims to provide for biodiversity conservation, sustainable use, and equitable access and benefit sharing.
The National Environmental Management Protected Areas Act (NEMPA), Act No 57 of 2003.	The act was promulgated in 2003 and aims amongst others, to redress the inequities and injustice regarding the establishment and development of South Africa`s protected area networks. (Rumsey & King,2009).

Conservation of Agricultural Resource Act, Act No 43 of 1983(CARA).	Repealed the Soil Conservation Act 76 of 1969 and the Weeds Act of 1937. The objectives of the act are to provide conservation of natural agricultural resources of the Republic by means of the maintenance of the production potential of land, by combating and prevention of erosion and weakening or destruction of the sources, and by protection of the vegetation and the combating of weeds and invader plants. Having considered these objectives, the principal purposes of the act as explained in the parliament are to consolidate all measures concerning soil utilisation and conservation and to transfer from the minister to a functionary the power to make general day- to- day decisions (SA,1983).
National Veld and Forest Fires Act no 101 of 1998	Controlled in terms of the National Veld and Forest Fire Act, Act No 101 of 1998, and the purpose of the act is to prevent and combat forest and mountain fires throughout the Republic. The act focuses on the establishment of fire protection associations by landowners. Amongst other things, a fire protection association must develop and apply a veld fire management strategy for its area, provide for agreed mechanisms for coordination of activities with adjoining fire protection association in the strategy, make rules that bind its members, and provide management services (SA,1998).
National Forest Act, Act 84 0f 1998.	The purpose of the act is to: (a) promote sustainable management and development of forests and trees for benefit of all; (b) provide special measures for the protection of forests and trees; (c) promote sustainable use of forests for environmental, economic, educational, recreational, cultural, health, and spiritual purposes. The minister may declare trees as champion trees and a notice of declaration of such tree/trees is published in government gazette. According to section 12(1), the minister may declare: (a) a particular tree (b) a particular group of trees

	(c) a particular woodland d) or a tree belonging to a particular species to be protected. In terms of section 15(1) of the act no person may (a) cut, disturb, damage, destroy or remove any protected tree or (b) collect, remove, transport, export, purchase, sell, donate, or in any other manner acquire or dispose of any protected tree except under the license granted by the minister (SA,1998). A permit or license is available from offices of the Department of Agriculture, Forestry, and fisheries throughout the country. A list of protected trees is published in the government gazette every year Sustainable forest management can be achieved by complying with the principles of the act. To promote these principles, the minister of forestry must clarify the criteria, indicators, and appropriate standards in the form of regulations and these must be published in the media (SA,1998; Du plessis *et al*. 2009).

2.10. Biosphere reserve

Biosphere reserves serve as special places for people and nature. The biosphere reserves address biodiversity conservation and social, ecological, and cultural aspects of a given region. Biosphere reserves offer models of sustainable development in action and are the embodiment of the ecosystem approach adopted under the Convention on Biological Biodiversity (UNESCO, 2002; Bridgewater, 2002).

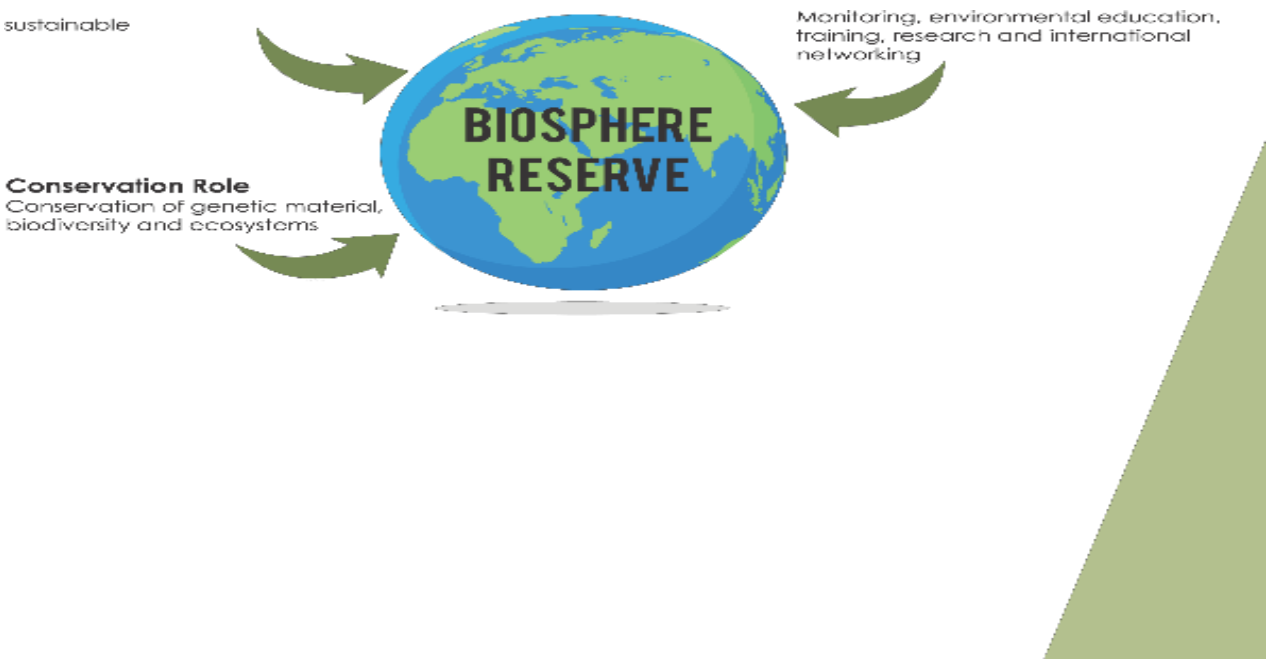

Figure 2.5. Biosphere Reserve

Biosphere reserves have to fulfill three interconnected functions:(a)around conservation, they must contribute to the conservation of landscapes, ecosystems, species, and genetic variation,(b) around sustainable development they must foster economic and human development which are culturally and ecologically sustainable, and (c)around logistic support: they must support demonstration projects, environmental education and training, research and monitoring related to local, regional, national, and global issues and as well as conservation and sustainable development(Bridgewater, 2002).

2.10.1. South African Biosphere Reserves

There are ten biosphere reserves in South Africa : Kogelberg biosphere reserves, Cape West Coast Biosphere Reserve, Kruger to Canyon Biosphere Reserve, Waterberg Biosphere Reserve, Cape Winelands Biosphere Reserve, Vhembe Biosphere Reserve, Couritz Cluster Biosphere Reserve, Magaliesberg Biosphere Reserve, Garden Route Biosphere Reserve, and Marico Biosphere Reserve. Collectively, they cover115732km^2 or approximately 9.5% of the country`s land area. All are members of the South African Biosphere Company that facilitates collaborated fundraising towards fulfilling the three biosphere reserve functions. They contribute considerably towards job creation and increased livelihoods as they secure a large percentage of the sources of major rivers, providing water to residents, agriculture, and business. They play a major role in assisting the national government to achieve the 17 SDGs and 20 Aichi Biodiversity Targets (UNESCO, 2002).

In the early 1960s, Magaliesberg was conserved by an important activist campaign that was launched because of damage from unplanned development, recreation, and over-

utilisation. Local and national initiatives were formed which ultimately came to involve landowners, recreation, and cultural and nature conservation interests as well as various tiers of government. Hostile contests over the Magaliesberg eventually ended with the unification of interests and the evolution of suitable legal planning and management tools (Carruthers, 2002; Carruthers, 2015).

The Magaliesberg Biosphere covers an area of 360 000 hectares and extends approximately 120km west to east across the boundary of the North West and Gauteng Provinces of South Africa, spanning the Magaliesberg mountains between the cities of Rustenburg in the west and Pretoria in the east. The north-south extent is approximately 40km and is marked by the N4 Platinum Highway to the north, and the N14 Pretoria-Krugersdorp Highway to the south, where the latter coincides with the north-western boundary of Johannesburg city (Cooper, 2015).

2.11. Summary

Several policies implemented by the government regard the impact of land use on biodiversity to be a critical issue. Biodiversity is a critical natural resource that is strongly associated with the ability of an ecosystem to provide ecosystem services. Land use has, on one hand, created valuable cultural landscapes, some of which have achieved protected status under UNESCO.

There has been much research and discussion conducted on land use and biodiversity. The reviewed literature indicates the agreement that land use and cover change have been the most visible indicators of human footprint and the driver of the most considerable loss of biodiversity and other forms of land degradation. The literature provides strong arguments on the availability of some land management options that can preserve biodiversity and has established that it is possible to balance land use with biodiversity conservation.

The purpose of the literature review in the present project is to examine past and current states of knowledge centred on land use and biodiversity and relate these to the proposed area, the topic of an example of better practice in urban biodiversity conservation, a traditional healer who is practicing sustainable land use and conserving biodiversity within the area

CHAPTER 3

METHODOLOGY

3.1. Study area

The study was conducted within and adjacent to the Magalies mountain ridge in Mamelodi (Tshwane), South Africa. The Mothong African Heritage site lies in Section H, C2 municipal ward 67 between Mamelodi West Township and Magaliesberg, which forms part of the Magaliesberg Biosphere Reserve (Figure 3.1). The latter from North West Province to Gauteng, as indicated, and has been recognised by the UNs, Educational, Scientific, and Cultural Organisation (UNESCO, 2002). The area was degraded and concomitant with ongoing security concerns, but now provides multiple uses to the community.

The Pretoria City Council (PCC) bought portion 2 and 3 of the Vlakfontein 329JR farmland to establish a black urban area, namely Mamelodi (Walker and Van der Waal, 1991). Development started west of Pienaar`s river in Part 3 and, due to population growth, Mamelodi West became fully occupied, resulting in the settlement expanding over the Pienaar`s river, which was initially the eastern boundary of the township. Because Mamelodi West was fully occupied, 80% of the residents moved into the locations of Bantule, Eastwood, and Lady Selborne (Chiloane, 1990). The apartheid regime relocated them according to race, ethnicity, and development of boundaries among neighbourhoods. People have continued to stay in ethnic groupings, and sometimes conflict occurs among them (SAHO,2016).

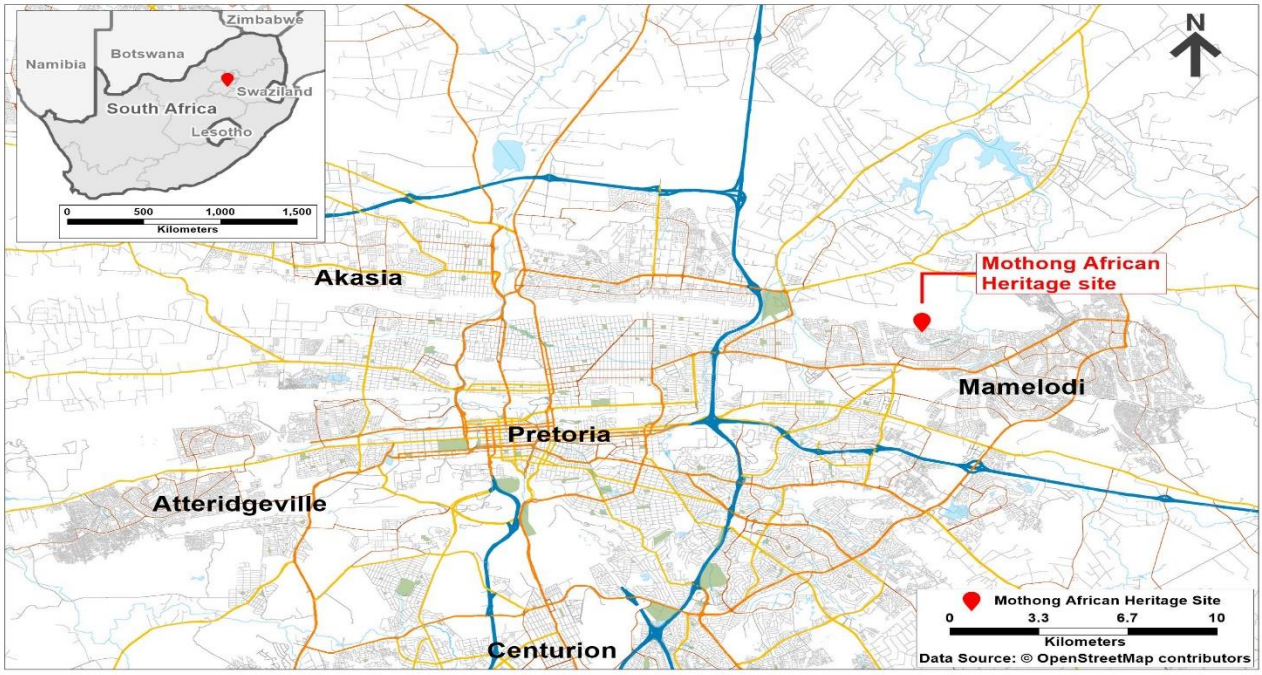

Figure 3.1. Mamelodi Township and Mothong African Heritage site

3.2. Geographical location of the study site

Mothong African Heritage site is located on geographical coordinates 25˚ 41' 51" S 28˚ 20' 17"" E.

Figure 3.2. Mothong African Heritage site nursery

Mamelodi is located in the eastern parts of the greater city of Tshwane within the Greater Gauteng Province of South Africa and lies between Magaliesberg and the industrialised area of Silverton. It is located on the periphery of the city of Tshwane, with its northern edge defined by the Magaliesberg mountain range. It is a residential suburb and is 45.19km^2 in size. It spreads in an east-west direction and is split into Mamelodi East and West by the Pienaar`s river.

There are many informal settlements in the township, where the majority suffers from poor infrastructure. It is expanding to the east-west lying escarpment of the Magaliesberg - however, the expansion area is limited. Development on the western side is restricted by the cemetery that borders Eersterus. The Magaliesberg itself (Van der Hoven,2018) restricts the northern part, which hosts the rapidly developing semi-urban areas of Derdepoort, Baviaanspoort, and Roodeplaatdam.

As indicated , natural zones and biodiversity of the area bordering the Magaliesberg region are under pressure due to current land-use practices. The pressure is caused by the high demand for housing and poor land-management practices. The early signs of urban sprawl encroaching on the foot of the mountain are visible and these are likely to have negative impacts on the natural landscape of the Magaliesberg. Socio-economic and development pressures characterise the section of the Magaliesberg adjacent to the township of Mamelodi, leading to the degradation of resources and biodiversity (Van der Hoven. 2018).

Figure 3.3. Mothong African Heritage site botanical garden

Magaliesberg mountain range is regarded as a natural feature with high biodiversity value (GDARD, 2011). Protecting Magaliesberg ridge will assist the conservation of biodiversity in the region. The 1999 ecological assessment does not support the fencing of the mountain for conservation and protection from the township to control urban sprawl. The area was placed under environmental protection by Mr. Mabena in 2001, and the Magaliesberg ridge forms part of the area designated as the Magaliesberg Biosphere Reserve by UNESCO in 2015.

Figure 3.4. Magaliesberg Mountain

3.3. Research design

The study employed a mixed method design, using qualitative and quantitative approaches to obtain the required data. The combined methodology focused on obtaining the data through observation and conducting interviews as well as recording all the responses so as to interpret their meaning. The information obtained from respondents assists in understanding the data to be analysed.

3.4. Sample design and sampling methods

The study used purposive sampling, using key informant 1, his wife, and the woman who assisted the two in the management of the area as the key informants. The three were chosen as key informants because of their significant knowledge and responsibility within the area. Purposive sampling, also known as judgmental, selective, or subjective sampling, is a form of non-probability sampling in which researchers rely on their judgment when choosing members of the population to participate in their study (Mc Combes, 2019). The researcher collects information from the best- fit participants and the results are relevant to the research context (Black, 2010).

After purposive sampling, snowball sampling was applied. Snowball sampling, also called chain referral sampling, is a method that yields a study sample through referrals made among people who share or know of others who possess some characteristics that are of research interest (Biernacki & Waldorf, 1991; Etikan *et a*l.2015). The use of locators in snowball sampling assumes that knowledge is differentially distributed and that certain persons, because of their past or present situations, have greater accessibility and knowledge about a specific area of life than do others (Biernacki & Waldorf, 1991). This sampling method involves a primary data source nominating other potential data sources that will be able to participate in the research studies. Although there are several variants of it, this approach involves a minimum of two stages: (a) the identification of a sample of respondents with characteristics x at the zero-stage (s_0), and (b) the solicitation of referrals to other potentially eligible respondents believed to have characteristics x at snowball stage s_1 through s_k (Heckathorn, 2002).

Due to the significant knowledge that the key informants possess of the focus area , they able to introduce beneficiaries of the site to the study. Benefits provided by the site included cultural ones, spiritual/religious ones, livestock grazing, initiation school, medicinal collectors, and firewood. The area further served the community in terms of outdoor activities: walking in the forest, hiking, training, and traditional gathering. Amongst those referred by key informants included a Rastafarian community residing adjacent to the site. Individuals were contacted first after having been referred to the research by key informants, and they in turn introduced other members to the researcher. The targeted sample population was 60. However, a final sample of 40 respondents was achieved, based on respondents who showed interest and agreed to take part in the study. This consisted of 62.5% males and 37.5% females.

Subsequently, the researcher obtained permission from the chairperson of the study area and visited the site. Site visits focused on those people visiting the site, and the purpose of the visit was to observe individuals who would fit the profile of those to be interviewed. Pre-testing of the study was an important way to pinpoint problem areas, reduce measurement error, reduce respondent burden, determine whether respondents are interpreting questions correctly, and ensure that the order of questions is not influencing the respondents' answer (see Grimm, 2010). The pre-test of the present questionnaire was undertaken with one staff member of the heritage site and one respondent chosen at the site, so as to prepare for the real administration of the questionnaire. Pre-testing was useful, as the researcher was able to obtain a real sense of what to expect around actual data collection.

3.5. Data collection methods and tools

The data collection method applied was the administration of a questionnaire (Appendix 1 and 2). Structured and semi-structured questions were developed and compiled into questionnaires, which were used as tools for collecting data (see Harrel & Bradley, 2009). For one-on-one sessions, the researcher used questionnaires whereas, for focus group discussions, topics related to the objectives of the study were used and were drawn from the questionnaires. One set of questionnaires was prepared for the individual respondents and the key informants – however, the additional information was prepared for the founder and manager of the site, so as to obtain information that would be different from the information that could be obtained from other respondents, such as the reason for the establishment of the heritage site. All respondents gave their consent to participate in the study by signing the consent form, as required by the university ethics procedures.

Besides questionnaires, as mentioned, the study was conducted by using focus group discussions and field surveys. Field surveys facilitated the collection of local-level information that was not available among secondary sources and enabled the researcher to comprehend the situation and processes in totality and the place of their occurrence. This was made possible, as mentioned, through ‘observation’, which is a useful method for gathering information and then deriving inferences from it (Sauro, 2015).

The questionnaire was divided into five sections covering all the objectives of the study. Section 1 covered the socio-economic profile, Section 2 the knowledge on land use and biodiversity, Section 3 knowledge on biodiversity conservation, Section 4 the importance/use of the study site, and Section 5 the use of resources within the study site (Appendix 2).

The languages that were spoken in the four sections of Mamelodi near the study site were Setswana, Isizulu, Tsonga, and Tshivenda – however, the dominant language was Setswana, also used as a language for interpreting the present project, so that the respondents would be able to understand the questions clearly. Language differences played a role when interpreting was required. Language differences might have affected the understanding and interpretation of the meanings in different phases during the administration of the questionnaires. The risk of losing the original meaning was taken into

consideration. The risk was minimised by asking the same question in the other three languages, and questions were repeated before and after completion of the questionnaire by using examples related to the topic that was discussed so to enable the respondents to relate to their experiences (see Zavala-Rojas, 2014).

3.5.1. Key informants

According to Rubin and Rubin (1995), selected informants should be "knowledgeable" about the experience or situation, willing to talk, and representative of a range of points of view. Key informants, as indicated earlier, included members of Group 1: key informant 1 and his wife, and key informant 2 who was working at the study site, as they had started the project together and still formed part of it. The key informants were involved in the day-to-day management of the site. The members knew each other, worked together, and enjoyed in-depth knowledge of the site. As indicated, the chairperson was the founder, he was thus included in the questionnaire survey first as part of the key informants' interviewees (Appendix 1 and 2).

The key informants were individually interviewed using semi-structured interviews, which served as a guide for the researcher to ask similar questions to the respondents and to remain focused. They were designed to capture specific as well as general information. It was possible to probe for more information when necessitated by the situation so as to obtain more clarity. It was important during the initial stage to gain source-specific information while allowing the respondents to air their views.

The technique derived from key informants was prioritised as the first step in data collection and therefore heralded the subsequent methods. This was critical, since the key informants were responsible for the management of the site and were familiar with what was happening in and around the study site. They committed themselves to assist around information related to the study site, tree identification, as well as user groups, which boiled down to critical information for the objectives of the study.

3.5.2. Household survey

The households were used as sampling units of the study to collect comprehensive and diverse socio-demographic data about conditions under which people live - their welfare, demographic characteristics, and the cultural factors that influenced behaviour, as well as social and economic change. The household head was targeted as the representative of the interview. A structured questionnaire was used to collect data from the sampled households. The household visits were fruitful, as the researcher saw the living conditions to form part of their respondents as part of their socio-economic profile and saw some of the products from the study site, which also partly dovetailed with comprised questionnaire topics. These visits included a visit to the surgery of the chairperson of the study site, where the researcher saw different herbs, medicinal plants, and animal products used for healing purposes, which which again dovetailed with the issues raised in the questionnaires. It also served as a useful opportunity for the researcher to engage with the patients who believed

in traditional practices and indigenous medicines. The visited client was from a Rasta family (see Figure 3.5 and Figure 3.6).

Figure 3.5. Household interview with a member of the Rasta family

Figure 3.6. Rasta`s residence

Both photos by Ramatlhape Tshegofatso 8 June 2020

3.5.3. Individual questionnaire

A questionnaire was administered to a range of respondents: religious/spiritual groups, cultural groups, cattle herders, and medicinal plant collectors, and those involved in outdoor activities. and all issues in the questionnaire were covered. As mentioned, the researcher was able to witness some of these issues, including where the prayer sessions were held, the site of the initiation school, and where the cultural activities were performed.

Conducted with one respondent at a time, the semi-structured interviews employed closed and open-ended questions, and were accompanied by follow-up questions (see Adams, 2015). As stated, the interviewer used semi-structured questionnaires as an interview guide. Questions were prepared for the researcher to guide the interview with a view to the research objectives.

Figure 3.7 Questionnaire survey with religious groups

3.5.4. Focus group discussions

In this study, a focus group was found to be useful for exploring the knowledge, insight, and experience of people benefiting from the site. The group consisted of eight members, including traditional healers, spiritual groups, cultural groups, and resource collectors. They were part of the larger groups of individuals benefiting from the study site. Gender balance was maintained, as the group consisted of four males and four females. Participants shared similar demographic characteristics and shared their personal experiences. The key informants referred individuals to the project who then formed part of the group and the introduced members introduced other members with similar characteristics in terms of environmental and non-environmental benefits obtained from the site. For example, one livestock owner introduced another livestock owner to the researcher. The researcher prepared a checklist of issues discussed during the session. One focus group discussion was organised after members indicated that there was no need to split them in terms of

gender and age, and all were willing to fully participate when combined in one group. The focus group discussion was conducted with members facing one another.

3.5.4.1. Focus group analysis

The prepared checklist of the main topics covered in the group discussions were the following:

- The importance of biodiversity.
- Causes of biodiversity loss/decline.
- Biodiversity conservation.
- The importance of the site in terms of non-consumptive and consumptive uses.

During the focus group discussion, the researcher asked questions pertinently by using open-ended and generic questions. The main questions asked were as follows

- What do you think about biodiversity?
- What are the main causes of biodiversity decline/loss?
- How do you feel about the loss/decline?
- What are the benefits obtained from the site?

For accuracy in data analysis, participant responses were recorded by taking notes and recording using notebook and recorder with permission from the members.

Figure 3.8. Focus group discussion

3.5.4.2. Ethical considerations

At the onset of the investigation, participants were thoroughly briefed on all aspects of the survey research with the aid of a participant information letter circulating among all members to the sample size (N=40). The consent letter outlined the following;

- Nature, purpose, and duration of the study.
- The study would not employ any deceptive data collection techniques.
- Participants may withdraw from taking part in the study at any time without penalty.
- No foreseeable threat to researcher`s and participants` safety or well-being
- The project was submitted to the university ethics committee for clearance.

All information/contributions provided by participants were voluntary, anonymous, and confidential. All data collected would be stored securely and processed, following the Data Protection Act. Only the principal researcher and supervisors would see the results, the findings from the study would be used for ethical purposes would furthermore be accurately reported, and outcomes might be shared with tutors to assist future students.

3.6. Land use practices within and around the Mothong African Heritage Site

Table 3.1 below reflects the various types of land uses practiced within the study site for biodiversity conservation, recreation, and other non-consumptive use. Sustainable land uses within the study account for the potential trade-offs between biodiversity conservation, productive land uses, and ecosystem services.

Table 3.1. Categories of land use practices within the study site

Categories of land use practice	Activities
Agriculture	• Botanical garden where indigenous medicinal plants are raised. • Educational centre/place of learning and research.
Recreational land use	• Large open garden catering camping, cultural events, and traditional ceremonies, with scattered indigenous trees. • A bird sanctuary. • Hiking/ forest walks. • Weddings.
Grassland	• Open grassland harbouring insects and small animals such as porcupines, rabbits, and snakes.
Pastures	• Grazing area for livestock.
Woodland	• Provision of ecosystem services.

3.7. Reconnaissance survey and transect layout

A reconnaissance survey was conducted for data collection, determining accessibility of the area, determining vegetation density, and determining materials/equipment's that would be needed. The survey was conducted from June to November 2020.

3.7.1. Transect layout and plot establishment

A transect of 100 m was laid using a belt method. The position of the sample plot was recorded using a Ground Positioning System (GPS) devise. The 100 m transect was divided into four plots of 40 m x 40 m (Plot C), 60 m x 40 m (Plot D), 60 m x40 m (Plot A) and 60 m x 60 m (Plot B). Plots A, B, and D consisted of grasslands and a few scattered trees: as a result, plot C was chosen and analysed in view of the variety of species occurring on it that were used by the communities. The plot was divided into 16 quadrants of 10m x 10m (Figure 3.9).

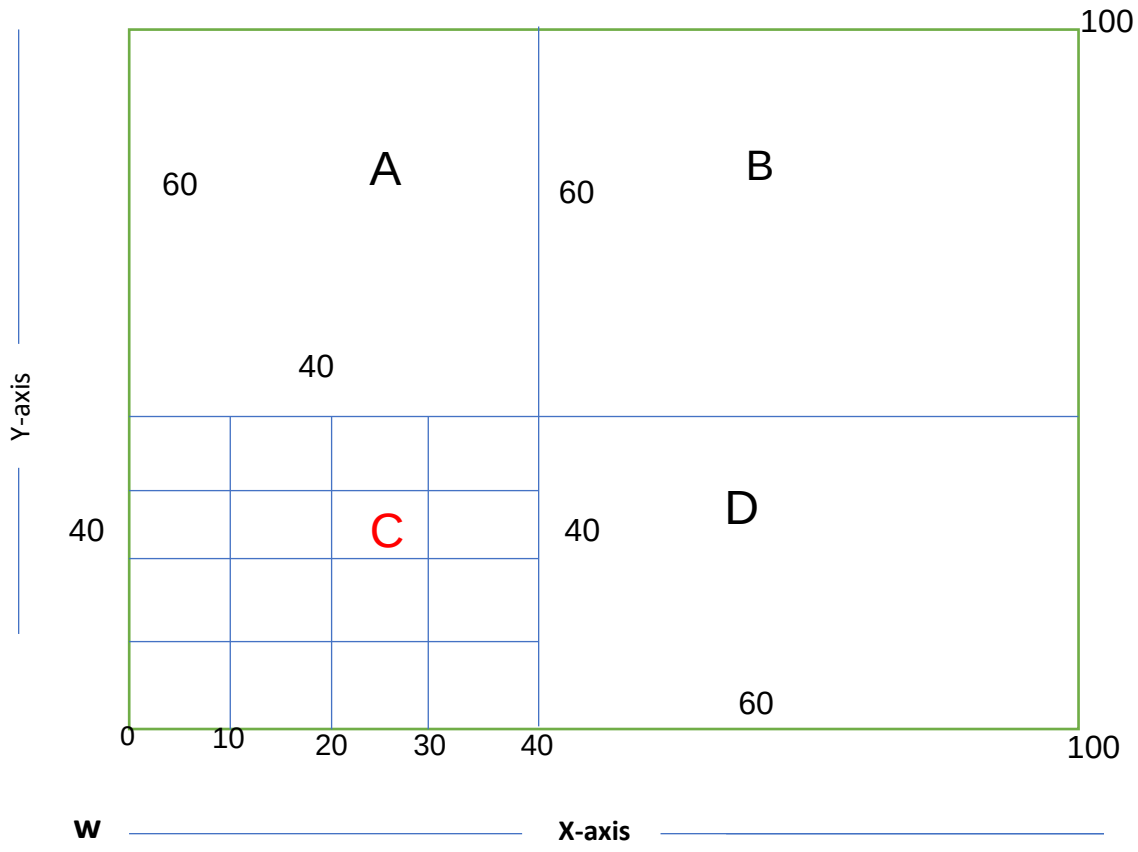

Figure 3.9. Sample plot layout and design

Figure 3.10. Vegetation within the sample plot

3.8. Vegetation sampling

Different species within sample plot C were identified and the number of species counted**.** Identification of the species of flora was done visually in the field, assisted by photographing the species of flora for later identification using the field guidebook, and with the assistance of Mr Mabena and Mr. Arnold Frisby from the University of Pretoria. Vegetation analysis was done to study species composition and the structure of the plant community.

3.8.1. Vegetation within the studied plot

Vegetation analysis of a plant community is an important aspect of ecological study of an area since it reveals the structural arrangements of various components of the plant community and helps understand the community dynamics (Patel *et al*. 2005). The basic count plot for trees was a10m x 10 m quadrant. In this study, of a 40 m x 40 m sample plot quadrant, trees having a diameter of ≥ five cm were enumerated by species and diameter at breast height(DBH). They were measured at 1.3 cm height above the ground (see Dallmeier, 1992). Stems below five cm were regarded to be those resorting under the rubric of regeneration and were not considered. Stems of five cm and above were regarded as usable trees.

Each plant community is characterised by its species diversity, growth forms, structures, and the dominance of successional trends, among others. With increase in human activities in and around forest ecosystems, biodiversity in terms of numbers of species may decline.

A sound understanding of the richness of species is necessary for appropriate conservation and restoration of the biological diversity. To know their dominance, they were analysed for frequency, density, abundance, diversity, species richness, and species evenness. Species dominance (most abundant species) in a community, where species exert a strong influence over the occurrence and distribution of other species, was obtained by calculating the total basal area of all species on which the relative dominance was determined. Relative dominance summed up with relative frequency and relative density were used to calculate an importance value index (IVI). This is a statistical measure, which gives an overall picture of the importance of the species in the vegetation community. It incorporates important parameters: which are measures of diversity and productivity of every species. The species diversity index was calculated following the Shannon-Weiner Index method (see Shannon & Weiner, 1963). Diversity along with species richness was measured using Pielou`s evenness index. Species richness was calculated by counting the total number of different species represented in the community, whereas species abundance comprised the number of individuals per species, and the species dominance index was calculated by following the Simpson formula (see Simpson, 1949) (Table 3.2).

Table 3.2. Vegetation parameters and biodiversity indexes

No	Parameter	Definition	Formula
1.	Frequency	Frequency is the number of times a plant species occurs in each quadrant (Fatima & Mahajan, 2017).	% frequency= Number of individuals occurring in all quadrants / Total number of individuals in all quadrants χ100 Relative frequency = Frequency of a species / Total frequencies of all species X100 Total frequency = Sum of all quadrats occupied by all species / Number of quadrants
2.	Frequency class distribution	Diameter class or height class to show the stand or species condition with respect to future sustainability and management interventions (Travlos *et al*.2018).	Frequency= Number of quadrants in which species occur / Total number of quadrants studies
3.	Density	The number of individuals of each species per unit area (Brix & Andreasen, 2000).	Density = Total number of individuals of species / Total number of quadrants used in the sampling
4.	Abundance Relative abundance	Abundance refers to the number of individuals of species in an area (Booth *et al.2003).* The extent to which a species is common or rare a species is relative to other species in a given location (Travlos *et al*, 2018).	Abundance= Total number of individuals of a species in all quadrants / Total number of quadrats in which the species occur Relative abundance= Abundance of a species / Total abundance of all species

5.	Relative density	The numerical strength of a target species in relation to the total number of individuals of all the species that occurred in the given area(see Booth *et al*. 2010; Travlos et al.2018).	Relative density= $\frac{\text{Density of individuals of species}}{\text{Total densities of all individuals of all species}} X100$
6.	Species diversity	Diversity measure comprises two factors: species richness, that is, number of species, and evenness (sometimes known as equitability), that is, how equally abundant the species are (Rafferty *et al*, 2011).	total number of species recorded that is often described as alpha diversity or species richness
7.	Shannon Diversity Index	Used to characterise species diversity in a community (Shannon & Weaver, 1963; MacDonald, 2003).	H' = - ∑Pi ln Pi (Pi) where p_i is the proportion of individuals belonging to the *i*th species and Sis the total number of species. The values of this index range between 1.5 and 3.5
8.	Pielou's Evenness J′	The evenness of a community can be measured by Pielo`s Evenness method which comprises the number derived from the Shannon diversity index and is the maximum possible value of (if every species was equally likely), equal to J (Jost, 2010).	J`= $\frac{H}{\ln(s)}$
9.	Species richness	The number of different species represented in an ecological community (Jost, 2010).	
10.	Dominance	A measure of the size, bulk, or weight of the vegetation. Three characteristics of the vegetation are commonly evaluated as a measure of dominance: weight, basal cover, or	Dominance=$\frac{\text{Total basal area}}{\text{Total area sampled}} X100$

		canopy (crown) cover or area (Ruthven, 1993).	Relative dominance= $\frac{\text{Dominance of given species}}{\text{Total dominance of all species}} \times 100$
11.	Basal area	The total cross-sectional area of all stems in a stand measured at breast height and expressed per unit of land area. To standardise measurements, tree diameter is typically measured at 1.3cm from the ground, or approximately breast height. This is referred to as diameter at breast height (DBH) (Joost, 2010).	Basal area= $\pi X(DBH/2)^2$ Basal area= $\frac{\pi d^2}{4}$ Elledge, J. 2010
12.	Simpson`s Index of Diversity	The index is a measure of both the richness and proportion (percentage) of each species. It is, therefore, a measure of dominance, meaning that a community with high diversity will have a low dominance value (Shannon & Weaver, 1963; MacDonald, 2003).	D= $\frac{\sum n(n-1)}{N(N-1)}$ D= 1- $\frac{\sum (n)^2}{(N)^2}$
13.	Importance Value Index	A measure of the extent of the dominance a species is in a forest area. It considers the relative values of density, frequency, and basal area of every species in each area. It thus incorporates important parameters: which are measures of diversity and productivity of every species. Because the value combines relative cover, density, and frequency, importance value	Relative density = $\frac{\text{Density of species 1}}{\text{Total densities of species}} \times 100$ Relative frequency = $\frac{\text{Frequency of a species}}{\text{Total frequencies of species}} \times 100$ Thus, IVI = Relative density + Relative frequency + Relative dominance

		ranges from 0-300(Tauseef *et al*. 2012)	

CHAPTER 4

RESULTS

INTRODUCTION

This chapter gives an overview of the respondents in terms of demographic profile, knowledge of biodiversity, and the importance of biodiversity to them.

4.1. General demographic profile

The total number of respondents interviewed was 40, representing a 66.6% response rate of the sampled population (N=60, n=40). Results of the occupation of the respondents(n=40) indicated that 42.5% were self-employed, 12.5% were unemployed, while 45% were employed in various sectors. The results in Table 4.1 show that 62.5% were males. Females constituted 37.5% of the sample. The age of the respondents was divided into five categories. A total of 2.5% represented an age category of 18-20, 22.5% ,one of 20-29, 17.5% one of -39,20% age of 30-39, 20% one of 40-49, 27.5% one of 50-59, while 10% represent an age of over 60 years.

Results among the respondents (n=40) as regards education level indicated that 15.0% completed the primary level and 42.5% completed secondary level, while 42.5% obtained tertiary education. Results of the respondents about residential status indicated that 17.5% were not indigenous to Mamelodi, whereas 82.5% were indigenous to the area. Respondents considered to have utilised the site came from five different sections: 22.5% were from section HC2, 47.5% from section JC3, ten % from section KC4, five % from section GC1, and 15% from other sections including Naledi and section 8.

Table 4.1. Participants` gender, age, level of education, occupation, residential status, and residence

Gender of participants	Frequency	Percentage
Male	25	62.5%
Female	15	37.5%
Total	**40**	**100%**
Participant's age		
18-19	1	2.5%
20-29	9	22.5%
30-39	7	17.5%
40-49	8	20%
50-59	11	27.5%
60+	4	10%
Total	**40**	**100%**
Participant's level of education		
Primary	6	15.0%
Secondary	17	42.5%
Tertiary	17	42.5%
Total	**40**	**100%**
Participant's occupation		

Self employed	17	42.5%
Unemployed	5	12.5%
Employed	18	45.0%
Total	**40**	**100%**
Participants residential status		
Migrant	7	17.5%
Indigenous	33	82.5%
Total	**40**	**100%**
Participants sections of residence		
Section HC2	9	22.5%
Section JC3	19	47.5%
Section KC4	4	10.0%
Section GC1	2	5.0%
Other	6	15.0%
Total	**40**	**100**

4.2. Demographic profile of focus group

As indicated below in Table 4.2, the focus group consisted of four males and four females.

Table 4.2. Gender of focus group members

Gender	Frequency	Percentage
Male	4	50%
Female	4	50%
	8	**100**%

4.3. Focus group discussion

4.3.1. The importance of biodiversity

Even though the group consisted of members benefiting from the site in various ways, there was consensus among members of the focus group that biodiversity was important to their lives. The main consensus was that biodiversity was important to the survival and welfare of the human population because of the impact on health and the ability to feed themselves through agriculture and wild food. Different ideas related to the importance of biodiversity were that biodiversity was an integral part of culture and identity. Species were integral to religious, cultural, and national identities and all major religions included elements of nature. Biodiversity provides humans with raw materials for consumption and production. Many livelihoods such as those of farmers, fisheries, and timber workers are dependent on biodiversity. Ecological services provided included functioning of the ecosystem, supply of oxygen, clean water, pollination of plants, and wastewater treatment. The group observed that recreation, included hiking, camping, and tourism were important while the cultural domain was found to include spiritual and aesthetic importance.

4.3.2. Causes of biodiversity decline

The consensus amongst the group members was that human actions were resulting in the decline/loss of biodiversity. Land-use changes, which are a focus of the study, contribute to biodiversity loss. The way people use biodiversity and overexploitation contribute to biodiversity loss. Pollution through illegal fires and illegal dumping were also seen as factors causing biodiversity decline at the study site.

4.3.3. Ways of conserving biodiversity

There was consensus that it is our responsibility to conserve biodiversity for present and future use. Some of the strategies mentioned for biodiversity conservation included sustainable use of the resources, planting of trees(which included community participation in programmes such as Arbor months), avoidance of pollution and deforestation, observing of environmental laws, protection of endangered species, and increasing public awareness of biodiversity conservation. Despite the consensus amongst the members that biodiversity conservation was everyone`s responsibility, they urged government departments to take a leading role in this respect.

4.3.4. Benefits offered by the study site

All members agreed that the site was important and beneficial to the communities in terms of environmental benefits coupled with forest resource use. They noted that the site also offered community benefits in terms of non-consumptive uses.

4.3.5. Analysing data for focus group discussion

The researcher elicited the main emerging ideas. Reactions and feelings of the participants were observed, and the balance among these were mostly considered. To properly report the work, the findings of the main ideas were summarised and presented.

4.4. Perceptions and sources of knowledge of biodiversity

Participants provided their opinions about their knowledge regarding biodiversity, the places where they heard about it, also by means of their participation in biodiversity discussions. As shown below in Table 4.3, 95.5% have heard the word biodiversity and only one respondent had never heard of it, while one respondent chose not to respond to the question. Results of the study indicated that 72.5% had heard about biodiversity from school,15% from media, and 7.5% from organised events.

Table 4.3. Knowledge about biodiversity

Participants who know about biodiversity	Frequency	Percentage
Yes	38	95.5%
No	1	2.5%
No response	1	2.5%
Total	**40**	**100**%
Where participants heard of biodiversity		
School	29	72.5

Media	6	15%
Organised events	3	7.5%
Neither of the above	2 **40**	5% **100**%

Results as to whether respondents have participated in discussions on biodiversity as shown below in Figure 4.1, which revealed that 47.5% had participated in biodiversity discussions, 50% had never participated in discussions on biodiversity, while 2.5% gave no response.

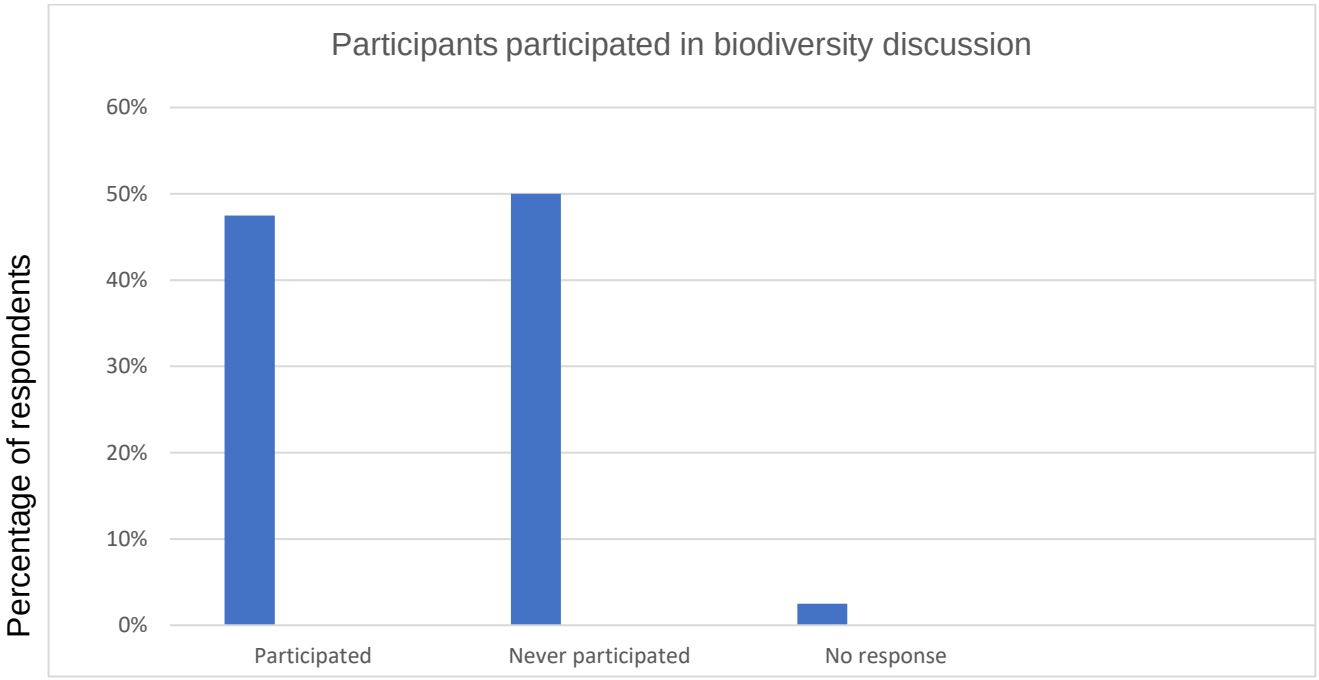

Figure 4.1. Participant's participation in biodiversity discussions

4.5. Source of knowledge about land use and participation in land use discussions

As shown below in Figure 4.2, the research findings revealed that 90% had heard about land use, 2.5% had never heard about it, and 7.5% gave no response.

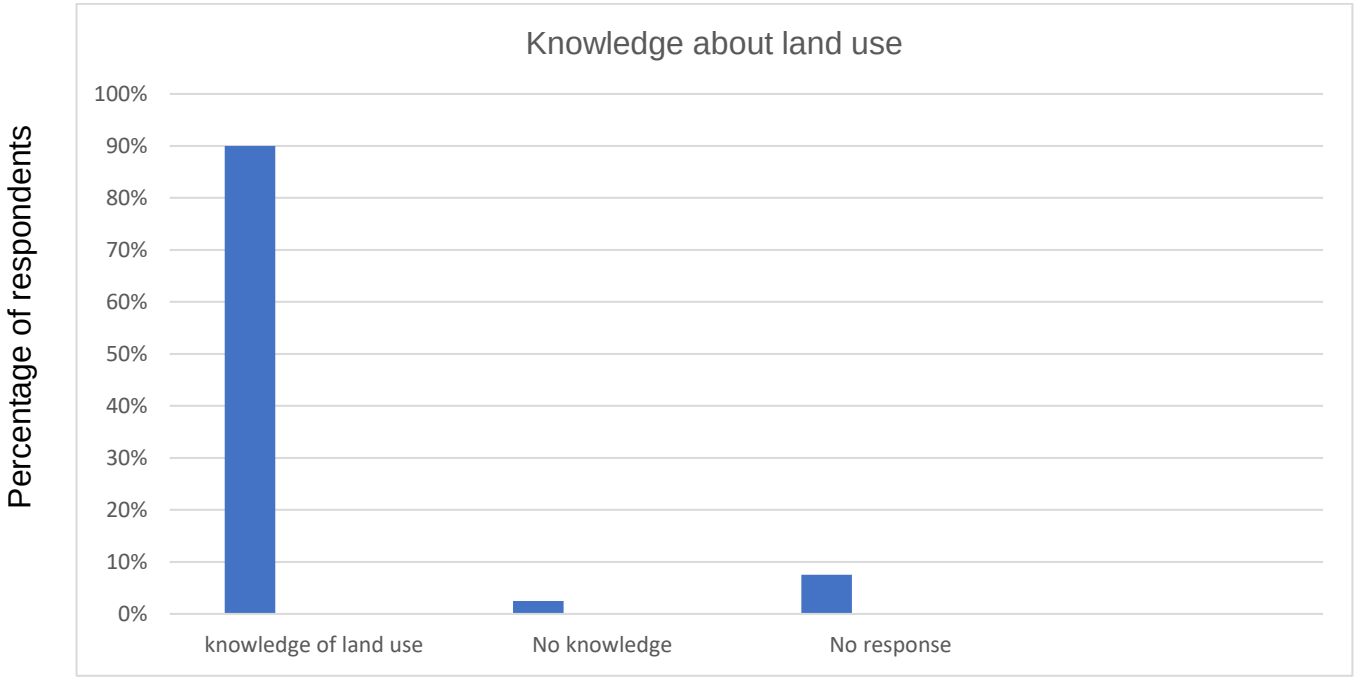

Figure 4.2. Knowledge about land use

The results as reflected in Figure 4.3 show that 65% had heard about land use from school, 12.5 % from the media, and 12.5% from the organised events, while 10% chose neither of the given options.

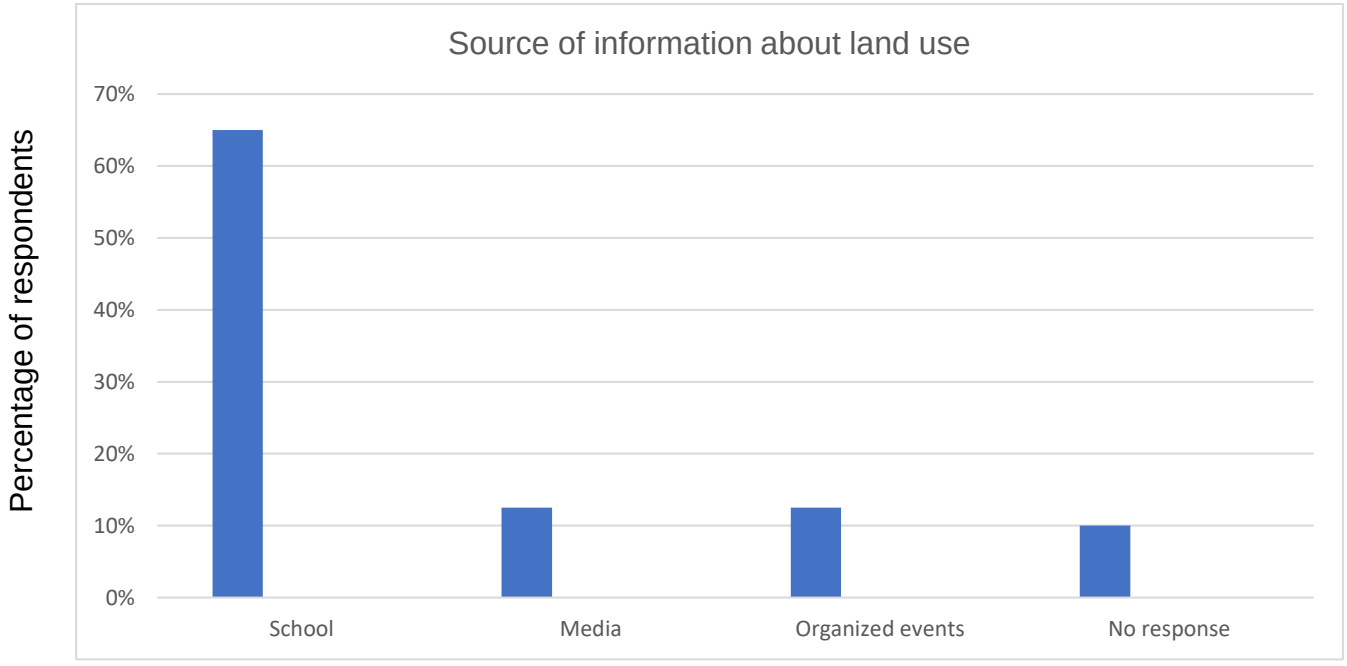

Figure 4.3. Source of information about land use

Results reflected in Figure 4.4 show that 37.5% had participated in the discussion on land use, 55% had never participated, and 7.5% gave no response to the question.

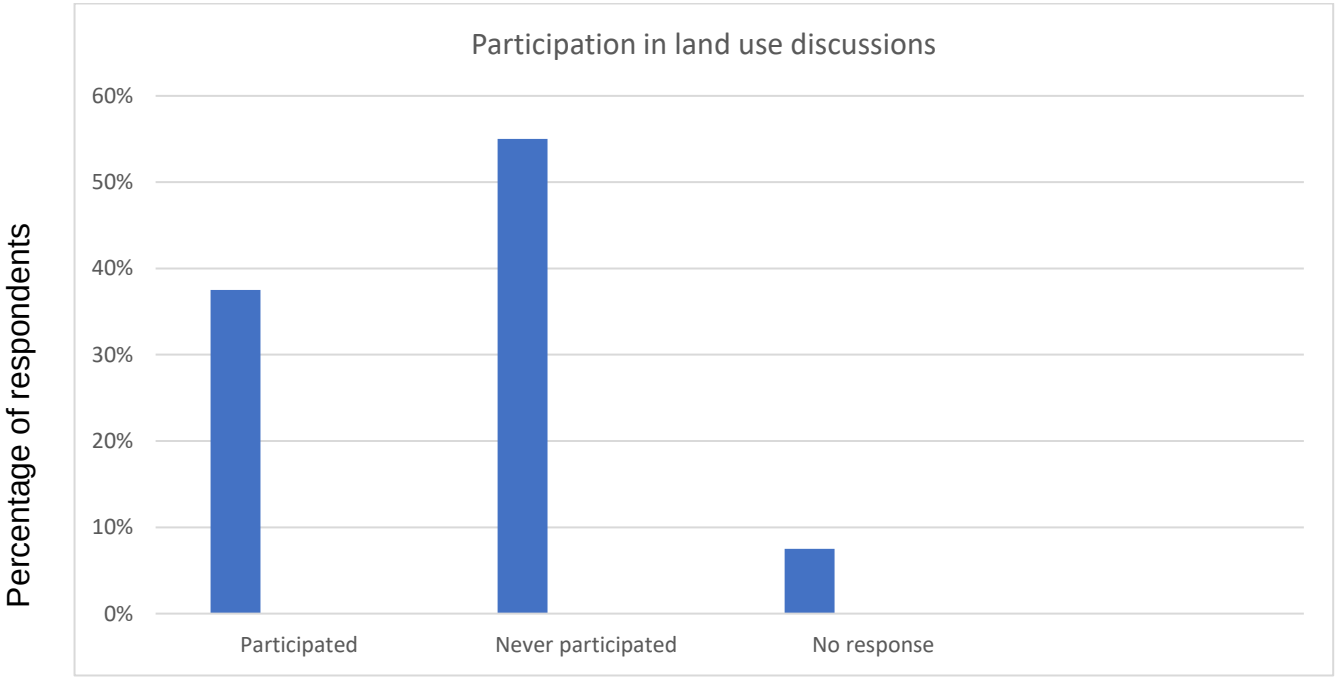

Figure 4.4. Participant`s discussion of land use

4.6. Relationship between land use and biodiversity

Results reflected in Table 4.4 reveal that 92.5% strongly agreed that there was a relationship between land use and biodiversity, while 7.5% neither agreed nor disagreed on this.

Table 4.4. Relationship between land use and biodiversity

Participants who think there is a relationship between land use and biodiversity	Frequency	Percentage
Strongly agree	37	92.5%
Neither agree nor disagree	3	7.5%
Total	**40**	100%

4.7. Biodiversity knowledge and conservation

Respondents were asked to indicate the status of biodiversity. Table 4.5 below shows that all of the respondents, 100% strongly agreed that biodiversity was under threat. Participants were asked to share their views on whether they thought they had a role to play in biodiversity conservation, and results revealed that 97.5% strongly agreed that they did , while 2.5% neither agreed nor disagreed.

Table 4.5. Biodiversity threats and conservation

Participants who think biodiversity is under threat	Frequency	Percentage
Yes	40	100%
T**otal**	**40**	**100%**
Participant's role in biodiversity conservation		
Strongly agree	39	97.5%
Neither agree nor disagree	1	2.5%
	40	**100**%

4.8. Perceptions on changes in biodiversity

Respondents were asked to indicate if they had noticed changes in biodiversity. Table 4.6 below shows that 97.5% strongly agreed that they did, while 2.5% disagreed (they had never noticed changes). The feelings of the respondents concerning biodiversity changes revealed that 97.5 % were very worried about this while, 2.5% opted not to respond to the question.

Table 4.6. Perceptions on changes in biodiversity

Participants who have noticed changes in biodiversity	Frequency	Percentage
Strongly agree	39	97.5%
Disagree	1	2.5%
	40	**100%**
Participants feelings about the changes	39	97.5%
	1	2.5%
	40	**100%**

4.9. Knowledge of environmental legislation and its effectiveness

Table 4.7 below shows that 62.5% of participants were aware of environmental legislation, while 37.5% were not. Participants were requested to rate the effectiveness of the environmental legislation, and results showed that 35% indicated that the legislation was partially effective, 27.5 % felt it was not, and 37.5% opted not to respond.

Table 4.7. Knowledge of environmental legislation and its effectiveness

Participants who were aware of environmental legislations	Frequency	Percentage
Yes	25	62.5%
No	15	37.5%
	40	100%
Participant's ratings of the effectiveness of the legislations		
Partially effective	14	35%

Not effective	11	27.5%
No response	15	37.5%
	40	**100%**

4.10. Knowledge about period of site existence

Results of Table 4.8 show that 12.5% had known the site for a period ranging between 1-5 years, 30% between 6-10 years, 12.5% period 11-15 years, 35% period 16-20 years, while 10% of respondents had known the site for over 20 years.

Table 4.8. Knowledge about period of existence of the site

Period over which participants had known the site	Frequency	Percentage
1-5 years	5	12.5%
6-10 years	12	30%
11- 15 years	5	12.5%
16-20 years	14	35%
+ 20 years	4	10%
	40	**100%**

4.11. Value- non consumptive use of the site value-non-consumptive uses and types

Table 4.9 below shows that all respondents agreed that the site was of value to the community. The community used the site for various non-consumptive activities. Non-consumptive uses included 30% for cultural use, 37.5 % for religious purposes, 17.5% for sporting activities, and 15% for use of livestock.

Table 4.9. Site use and value – non-consumptive uses and types

Participants who thought the site was useful to the community	Frequency	Percentage
yes	40	100%
Non-consumptive uses	**40**	**100%**
Types of non-consumptive uses		
Cultural uses	12	30%
Religious uses	15	37.5%
Sporting activities	7	17.5%
Livestock	6	15.0%
	40	**100%**

4.12 Biodiversity value to traditional healers and herbal medicine conservation

Results of Table 4.10 show that 90% indicated that biodiversity was important to traditional healers, 2.5% indicated that biodiversity was not important to the traditional healers, while 7.5% did not respond to the question. Results further revealed that 95% of the respondents felt that biodiversity was important, needed to be used sustainably, and should be protected,

while 5% gave no response. Table 4.11 reflects types of herbs and shrubs used by the community.

Table 4.10. Biodiversity value to traditional healers and herbal medicine conservation

Importance of biodiversity to traditional healers	Frequency	Percentage
Yes	36	90%
No	1	2.5%
No response	3	7.5%
	40	**100%**
Participants who felt herbal medicines needed to be conserved		
Yes	38	95%
No	0	0
No response	2	5%
	40	**100**

Table 4.11. Types of herbs and shrubs used by community

Herbs	**Uses**
Cannabis sativa	Glaucoma, nausea, asthma, appetite
Lippia javanica	Tea for colds, fever, bronchitis
Milkweed	Stomach pain, headache
Aloe	Laxative, skin irritation, bruises
African wormwood	Cough, cold, influenza, block nose
Bush tea	Heart disease
Boopane disticha	Septic wounds after circumcision
Lantana camara	Traditional medicines for treating variety of ailments including chicken pox, skin itches, measles
Lopholaena coriifolia	Can be used to treat convulsions
Xerophyte retinervis	Roots treat asthma and nose bleeds

4.13. Use of resources by family members

Respondents were requested to indicate if their family members used the resources within the site and results as reflected in Table 4.12 below show that 97.5% agreed that their family members used the resources, while 2.5% indicated that their family members did not.

Table 4. 12. Use of resources by family members

Family members involved in resource use	Frequency	Percentage
Yes	39	97.5%
No	1	2.5%
	40	**100%**

4.14. Value of forests-types of forest products

Results as indicated in Table 4.13 show that all respondents agreed that forests were important. Results further showed that 32.5% obtained medicines from the site, 57.5 % collected wild fruits, 7.5% collected firewood, while 2.5% did not respond.

Table 4.13. Value of forests -types of forest products

Participants who feel forests are important	Frequency	Percentage
Yes	40	100%
Forest products		
Medicines	13	32.5%
Wild fruits	23	57.5%
Firewood	3	7.5%
Grass	0	0
No response	1	2.5%
	40	**100**

Table 4.14. Species value to the community

Species	**Species value to the community**
Ochna pulchra	▪ Fruits are edible. ▪ Firewood. ▪ Mouth provides edible caterpillars. ▪ Hardwood is used for fence post, parquet, flooring, and furniture. ▪ Leaves treat infections and have antibacterial properties.
Burkea africana	▪ The hardwood is used for fence posts, parquet flooring, mortars, and attractive furniture. ▪ Provide caterpillars which serve as food for local people. ▪ Gum is edible.
Jacaranda mimosifolia	▪ Serves as an ornamental tree. ▪ Excellent source of nectar, fuel, carpentry, and poles. ▪ The tree has medicinal properties; however, these uses cannot

	compensate for the overall negative effects of using it for this purpose.
Englerophytum magalismontanum	▪ Fruits are edible and can be used for making syrup, jelly, jam, wine, vinegar, and an alcoholic drink known as mampoer. ▪ Medicinal value.
Vangueria infausta	▪ Medicinal value ▪ Fruits are eaten raw or stored as dried fruits. ▪ Can be used to make mampoer beer ▪ Edible caterpillars.
Strychnos spinosa	▪ Roots and leaves are used for medicinal purposes. ▪ Dried fruits, after seeds have been removed are often used as sounding boxes for musical instruments such as the marimba. ▪ The fruits are edible and often dried as food preserves. ▪ Timber can be used to produce implement handles, fighting sticks, and hut poles. ▪ Wood can be used for general carpentry.

4.15. Knowledge about biodiversity by level of education

Table 4.15 below reflects those four respondents with primary education had heard about biodiversity, while 1 such respondent had never heard about biodiversity, and a further one never responded. For respondents with secondary education, 17 had heard about biodiversity, while a further 17 respondents with tertiary education had heard of it. Results in Table 4.15 therefore indicate that biodiversity issues were discussed at secondary and tertiary levels.

Table 4. 15. Knowledge about biodiversity by level of education

Participant's level of education	Yes	No	No response	Total
Primary	4	1	1	6
Secondary	17	0	0	17
Tertiary	17	0	0	17
	38	**1**	**1**	**40**

4.16. Land use and level of education

Results of Table 4.16 below show that three of the respondents with primary education had not participated in such discussions, while a further three opted for a no response. A total of four respondents with secondary education had participated in such discussions, while 13 had not. A total of 11 respondents with tertiary education had participated in discussions, while six had not.

Table 4.16. Land use and level of education

Level of education	Yes	No	No response	Total
Primary	0	3	3	6
Secondary	4	13	0	17
Tertiary	11	6	0	17
	15	**22**	**3**	**40**

4.17. Tree species observed within the sample plot

A total of six species were recorded in the sample plot, namely - *Ochna pulchra*, *Burkea africana, Jacaranda mimosifolia, Strychnos spinosa, Vangueria infausta* and *Englerophytum magalismontanum*. (Pictures presented in Appendix 3).

Table 4.17. Species observed and recorded within the sample plot, within and around the Mothong African Heritage site

SN	Name of species	Quadrants employed in the study and number of individuals in each quadrant																Total number of individuals	Number of quadrates in which species occur (Y)	Total quadrants studies(Z)	% Frequency (Y/Z X100)	Frequency class	Abundance(iii/iv)	Density (iii/v)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16							
1	*Ochna pulchra*	0	26	12	11	9	75	68	21	43	57	42	4	23	29	38	9	467	15	16	86.8	E	31	29.2
2	*Burkea africana*	1	0	5	2	4	6	1	0	5	9	3	0	6	4	2	0	48	12	16	8.9	A	4	3
3	*Jacaranda mimosifolia*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	16	0.2	A	1	0.1
4	*Englerophytum magalismontanum*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	16	0.2	A	1	0.1
5	*Vangueria infausta*	0	3	2	4	0	0	2	0	0	1	0	0	3	0	4	0	19	7	16	3.5	A	2.7	1.2
6	*Strychnos spinosa*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2 **538**	2	16	0.4	A	1	0.1

4.18. Diameter class distribution

A total of 538 individual stems of six tree species were recorded in the sample area. Diameters of five cm and above within the 16 quadrants of sample plot C (figure 3.9) were enumerated and diameters were measured at 1.3 cm above the ground**.** For each species, diameters were measured and grouped into twelve categories (0 cm-60 cm)(Figure 4.6). Stem diameter is one of the most common measurements used to access the growth of woody vegetation and the commercial and the environmental benefits that it provides namely wood, biomass products, carbon sequestration, and landscape remediation, among others. Biodiversity within the study site was conserved and used sustainably for the benefit of the community in terms of use and non -use values. The species value to the community is illustrated in Table 4.14 and that for non-value in Table 4.9.The measurement of the woody vegetation is driven by the need to monitor and manage the various commercial and environmental outcomes they provide. Stem diameter was measured to determine both stand (basal area) and size frequency distribution. Table 4.18 indicates results found around of species dominance determination of all individual species sampled. The percentage distribution of individual species in different DBH showed among (Figure 4.5) the trees 29.7% belonged to the diameter class of 10-15cm and the lowest percentage,0.18% (40-45) cm was represented by DBH range. The largest DBH range of >50 cm comprised 1.1%. In terms of management, the sample plot had a young and vibrant population.

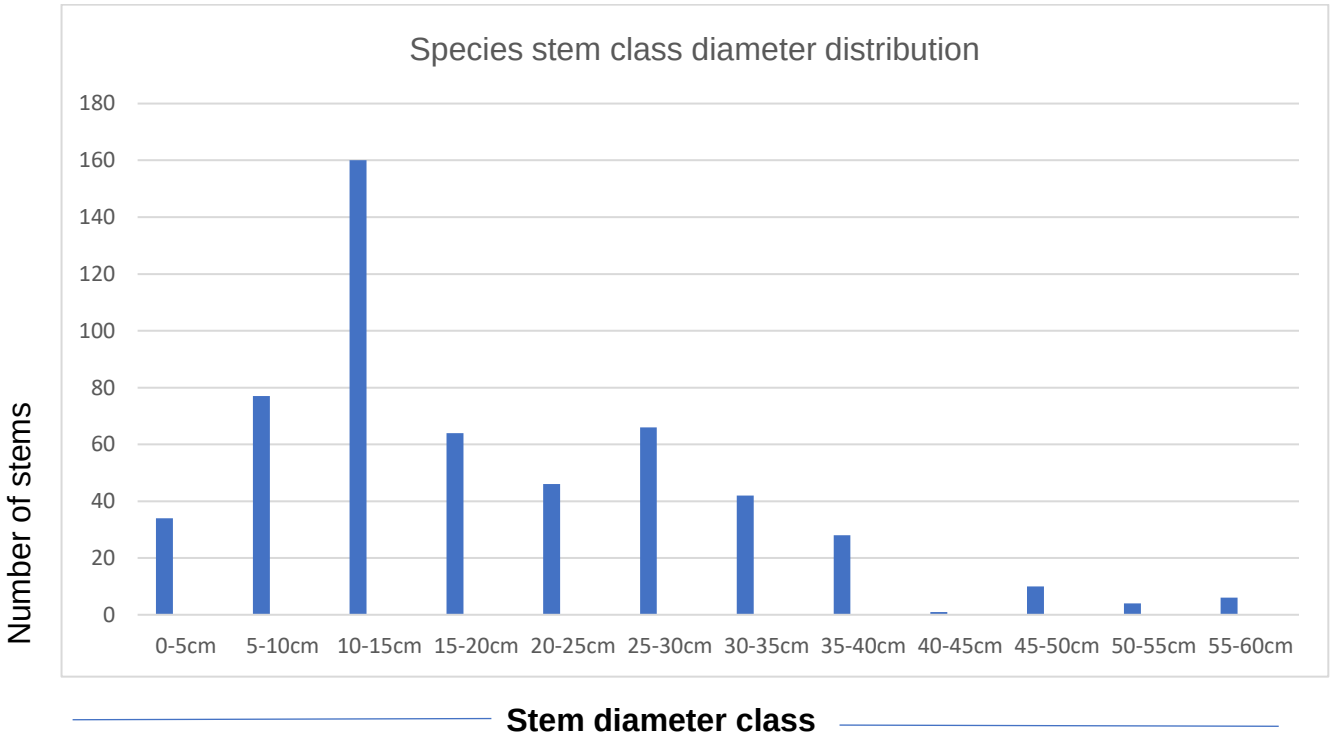

Figure 4.5. Stand stem diameter class distribution

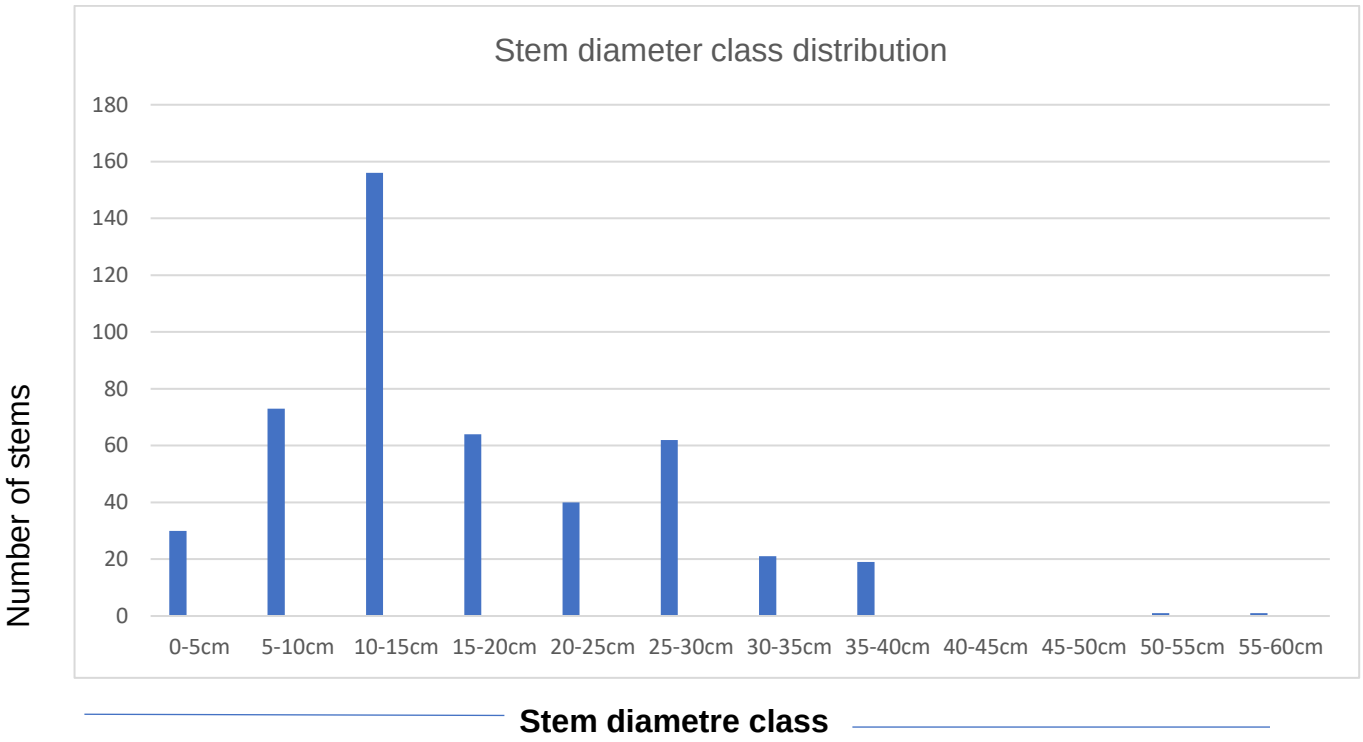

Figure 4.6. Stem diameter class distribution, *Ochna pulchra*

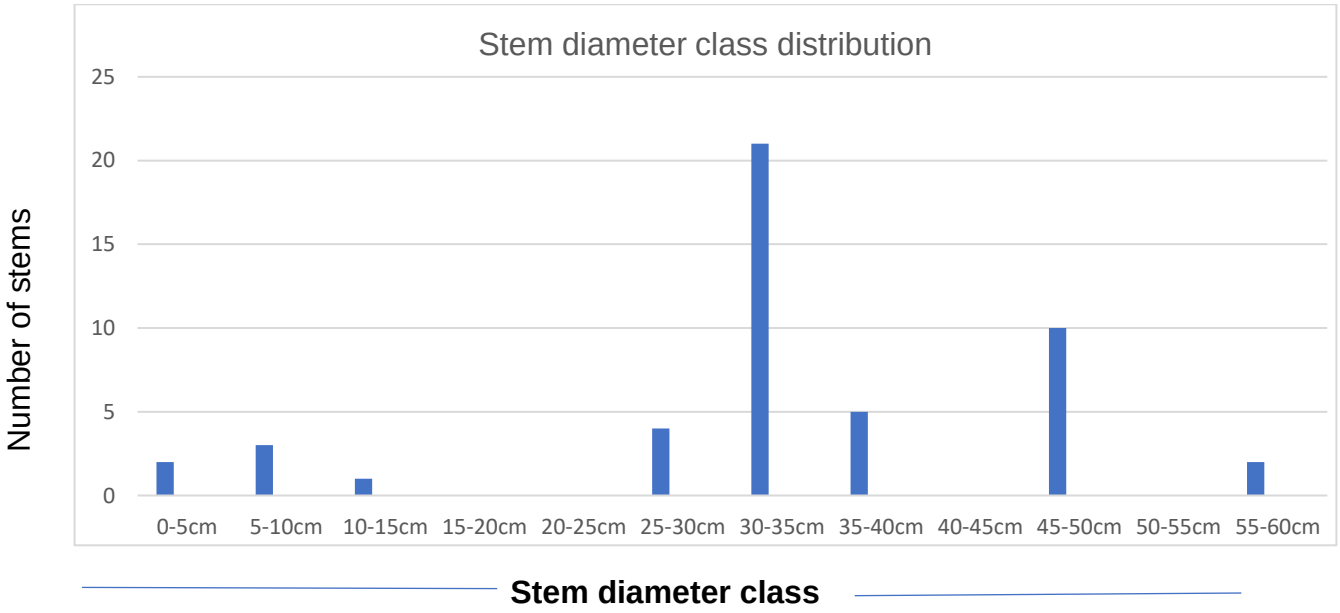

Figure 4.7. Stem diameter class distribution, *Burkea africana*

Figure 4.8. Stem diameter class distribution, *Jacaranda mimosifolia*

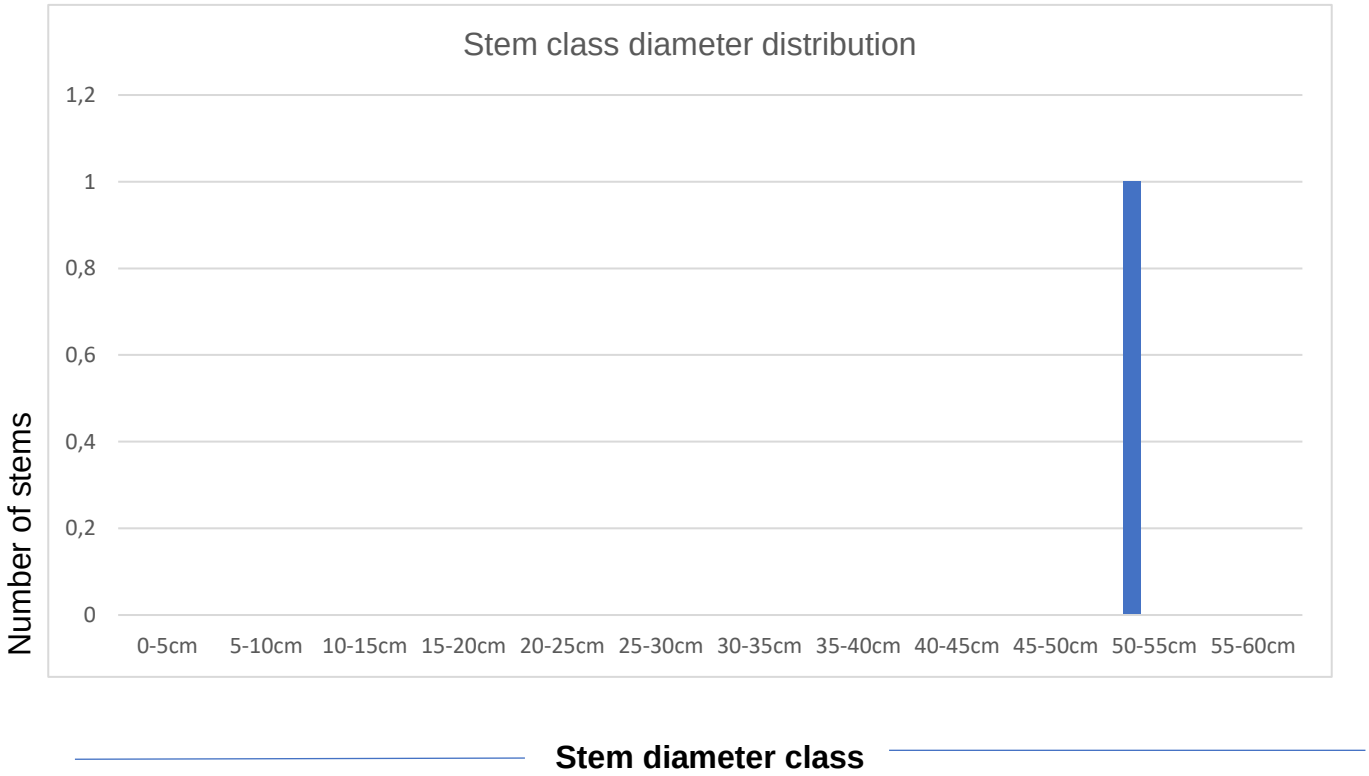

Figure 4.9. Stem diameter class distribution, *Englerophytum magalismontanum*

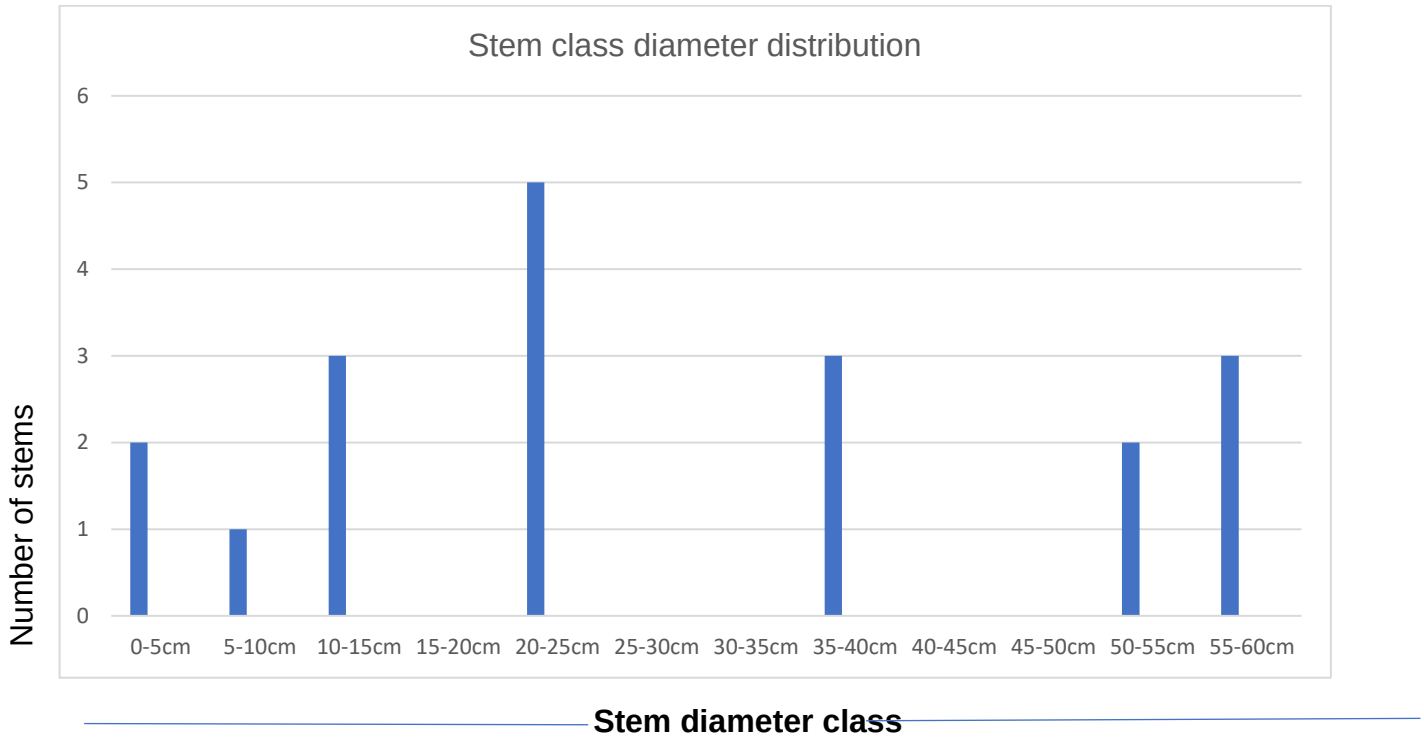

Figure 4.10. Stem diameter class distribution, Vangueria *infausta*

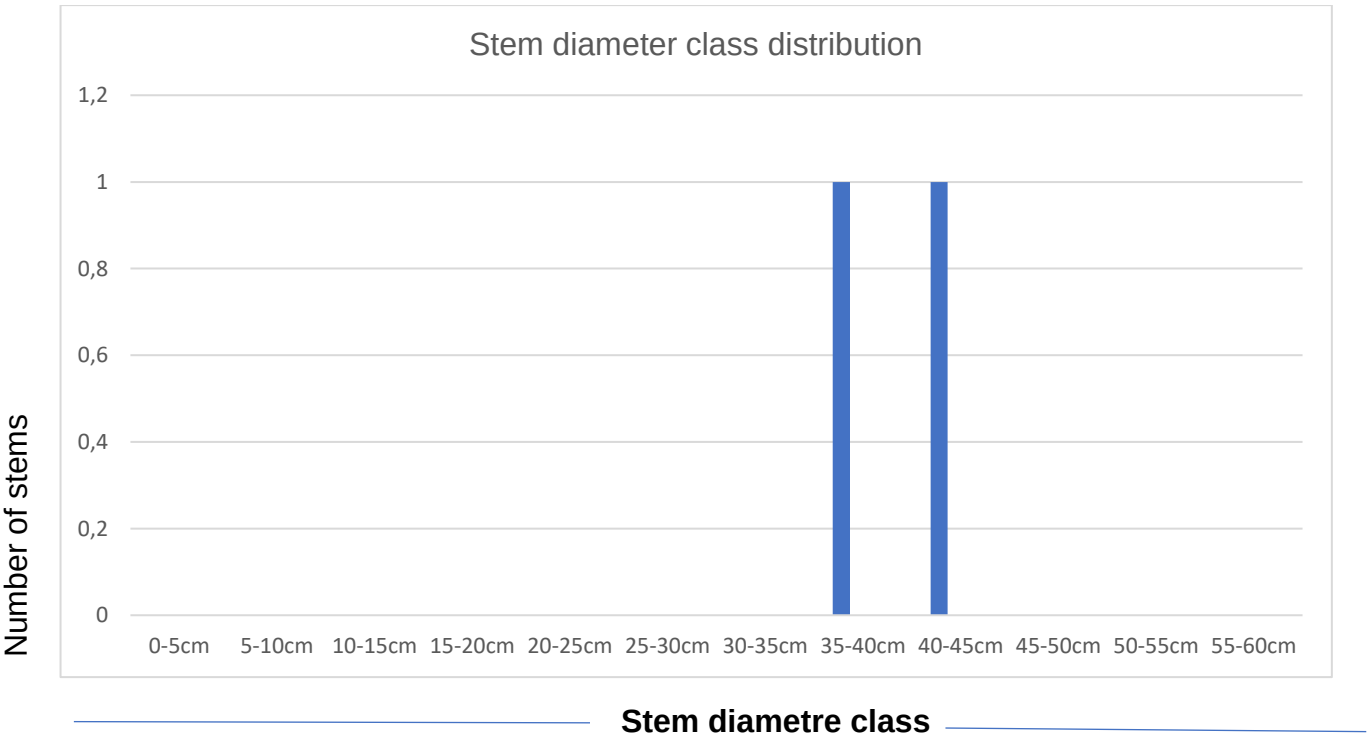

Figure 4.11. Stem diameter class distribution, *Strychnos spinosa*

4.19. Tree species composition

Species composition with respect to the study area indicates the species that constitute the plant community within it. This is important when we want to understand how an ecosystem works, and how important the different species are to the environment. Table 4.17 indicates the species composition within the sample plot studied. Species composition was determined by a sampling method based on assessing the contribution of individuals or species groups within a given in a sample. Within the context of each of the six different species types, frequency, abundance, and density were calculated, and the results indicate that *Ochna pulchra* has the highest frequency (86.8%), density (29.1) and abundance (31)as determined by using the formulas reflected in Table 3.2. The sampled plot had a species abundance of 538 with Ochna pulchra contributing the highest number, while *Jacaranda mimosifolia* and *Englerophytum magalismontanum* contributed the least number, namely 1 each. These two species contributed a frequency of 0.2% and a density of 0.1. *Ochna pulchra* showed the highest frequency and this might have been due to the species pool concept, that is the number of species adapted to a site that are available to colonise it, as well as greater ability to capture resources for growth and reproduction, resource availability and disturbance favouring the species, number of seeds capable of surviving generated by the trees, and low exploitation. Lower numbers for Jacaranda and *Englerophytum magalismontanum* within the sample plot might have been due to poor germinability, lean light from canopy trees, composition of nutrients, and high levels of exploitation - and for *Jacaranda mimosifolia* there was a possibility that it might have been introduced by wind or birds as agents, because the greater portion of the area outside the sample plot did not have this species, whereas *Englerophytum magalismontanum* was available outside the sample plot. The two species however needed to be managed for their importance value to the community, as also in the case of *Lantana camara*, that is nonetheless important for the community, which causes that it is managed better.

4.20. Tree species diversity

Table 4.18 is an overview of the tree species diversity. Species diversity is the number and relative abundance of species in each biological organisation. Habitat loss is the primary cause of decline in species and population. When more and more land uses occur within areas of high species richness, loss of biodiversity is greatly exacerbated, and species extinction increases. Land uses practiced within the study site were however conserving biodiversity, so that it was important to observe and study the tree species` diversity for proper planning so that, in turn biodiversity and healthy ecosystem would continue to play the role of maintaining ecosystem productivity and continue to provide benefits to community.

Basal area is the most common term used for describing the average amount of an area occupied by tree stems. It is more than just a forest stand - it is linked with timber stand volume and growth. Therefore, it is often the basis for making important forest management decisions such as estimating forest regeneration needs. The basal area for all species identified was calculated by using the formula cited in Table 3.2, and *Ochna pulchra* was found to have the highest basal area of 14.8,while *Jacaranda mimosifolia* and *Englerophytum magalismontanum* occupied the smallest basal area. Abundance, that is,

the extent to which common or rare species occur within an ecosystem is important, as it enables researchers to assess the ways in which different species are distributed throughout an ecosystem. Because species occupy the same trophic level, they will compete for similar resources. Understanding why some species are more abundant than others is particularly important, because communities that are strongly dominated by one or a few species often have a low species diversity overall.

Relative density for all species was determined so as to quantify the current density of a forest stand (basal area or stand density index) in comparison to maximum level. Identifying where stand growth may be stagnating or increasing aids efforts to predict future forest carbon stocks. The ability to measure forest stand density is fundamental for both description and prescription in applied ecology, including silviculture, forest health, and wildlife management.

The importance value index within the sample plot measures the extent to which a species in a studied sample plot is dominant. It is an important standard tool used in forest inventory. Tree species with diameter 5 cm and above were measured and the data were used to calculate the relative density and relative frequency of the species. The results were used to derive the importance value index, which determines the dominant tree species of the entire area under study and the value obtained was 232. The importance value index ranged from 0-300.The value indicated the complete or overall picture of ecological importance of the species within the study plot.

Table 4.18. Results of species dominance determination

Tree species	Parameters								
Scientific name	Basal Area	Frequency	Relative Frequency	Density	Relative Density	Abundance	Relative Abundance	Relative Dominance	Importance Value Index
1.Ochna pulchra	14.8	86.8	36.5	29.1	78.6	31	76	65	191
2.Burkea africana	5.5	8.9	3.7	3	8.1	4	9.7	24	21.5
3.Jacaranda mimosifolia	0.1	0.2	0.08	0.1	0.3	1	2.4	0.2	2.8
4.Englerophytum magalismontanum	0.2	0.2	0.08	0.1	0.3	1	2.4	1.1	2.8
5.Vangueria infausta	1.9	3.5	1.47	1.2	3.2	2.7	6.6	8.4	11.3
6.Strychnos spinosa	0.3	0.4	0.17	0.1	0.3	1	2.4	1.1	2.9
	22.8			37		41	99.5	99.9	232

4.21. Vegetation diversity indexes

Diversity of species and the measurement of diversity are of special interest to ecologists and natural resource managers. Biological communities vary in the number of species they contain(richness) and the relative abundance of these species (evenness). Species richness, as a measure on its own, does not consider the number of individuals of each species present. With reference to Table 4.19, species richness, as described in Table 3.1, simply indicates the different types of species in the sample plot – six of these in this case , whereas the species abundance, which refers to the number of individuals per species, is 538. To estimate diversity, the Shanno-Weiner index was used, whereas the Simpson index was used to calculate the species dominance. The Shannon diversity index was calculated by using the formula cited in Table 3.2, and the value obtained was 0.5. A diversity value of <1.5 indicates low diversity, a value between 1.5 and 2.5 indicates medium diversity, and > 2.5 indicates high diversity. Species number and relative abundance affect the diversity of an ecosystem. The greater the number of species the greater the stability of the ecosystem. The evenness and diversity of the species within the plot ware measured by using Pielou`s evenness and the calculated value was 0.07, while and Pielou`s evenness ranged from 0 (no evenness) to 1 (complete evenness). The Simpson Diversity Index was used to estimate the dominance of species in the sample plot, and the index value was 0.24. The range value of Simpson index ranged from 0 to 1, where higher scores close to 1 indicated high diversity.

Table 4. 19. Vegetation diversity indexes

Parameters	**Values**
Shannon Diversity Index(H)	0.5
Pielou evenness index(J)	0.07
Simpson index (Cd)	0.24
Species richness	6
Species abundance	538

CHAPTER 5

DISCUSSION

This study assesses the impact of land-use management and biodiversity conservation within and adjacent to the Magalies mountain ridge, in Mamelodi (Tshwane), South Africa. The present chapter presents a discussion of the socio-economic profile of respondent's, their understanding of land use and biodiversity, knowledge of biodiversity conservation, use of the site, and the importance of resources within and adjacent to the site. The discussion further considers the findings of the vegetation analysis by looking at its parameters so as to determine which species are abundant and which not, which need to be used sustainably, while ensuring their number is increased to provide further benefits, and how the identified species catered for community needs adjacent to the study site.

5.1. Demographic profile of the respondents

Results of the study showed that most community members had enjoyed primary and secondary education - however, the majority faced significant socio-economic challenges, ranging from unemployment, poverty, poor service delivery, and violence, to crime (ACMS, 2018). During the focus group discussions, respondents further indicated that most community members earned their living through short-term employment, locally known as ‘piece jobs’. The results further indicated that most of the respondents were self-employed, and majority of respondents were men.

The results indicated that most of the respondents were indigenous to the area, and they were aware of the study area and the multiple benefits it provided. Furthermore, the results indicated that four indigenous tribes were residing in Mamelodi: Vhavenda, Tswana, Tsonga/Shangaan, and Zulu - however, the dominant language spoken was found to be Tswana. Most of the respondents lived in the four sections of Mamelodi, with only four respondents from outside of Mamelodi - a possible indication that the area was starting to attract even people from outside Mamelodi.

5.2. Knowledge about period of existence of the study area

The Mothong African Heritage site was established in 2001 and, 19 years later, the site has become a place of environmental protection. The results of the study showed that a greater percentage of the community knew the site, due to the environmental benefits derived from it. A total of fourteen (14) respondents had known the site for over 16 years. The age categories involved in the study ranged between an age of 18 and an age over 60 years, and the results indicated that different age groups were aware of the site. The period of knowing the site corresponded with the period over which the respondents had lived in various sections of Mamelodi, which is the area adjacent to the study site.

5.3. Relationship between land use and biodiversity

The results of the study showed that 95.5% were aware of biodiversity, while 90% of the respondents knew about land use – an encouraging finding. Knowledge of the relationship between land use and biodiversity is critical for understanding the connection between

people and the environment. The results indicated that there was a relationship between biodiversity and land use. This was similar to the findings of a study conducted by Mayfield and Daily, (2005), which found that certain agricultural landscapes and traditional smallholder practices contributed to biodiversity conservation.

5.4. Source of information regarding biodiversity and land use

The results of the study indicated that formal education played an important role around educating people about biodiversity and land use. In the case of biodiversity, 72.5 % had heard about land use and biodiversity in formal education, 15% from the media, and 7.5 % from organised events. In the case of land use, 65% had heard about it in formal education, and 12% from the media and organised events. The results were an indication that people did know the importance of practicing land use that conserves biodiversity. In the study area, both indigenous knowledge practiced by Mr. Mabena, and environmental knowledge (related to formal education) possessed by participants was in fact found to be contributing to SLM and biodiversity conservation. Indigenous knowledge in general tends to play a significant role in the conservation of biodiversity. Traditional ecological knowledge and practices have been so successful (in certain areas) so that, although indigenous lands account for less than 22% of the world`s land area, traditional territories are home to approximately 80% of the world`s biodiversity (Rudle, 2019).

5.5. Biodiversity conservation and participants' role in biodiversity conservation

Results of the study indicate that all participants agreed that biodiversity was under threat from human activities, and that there was a need for sustainable use, while conservation measures needed to be in place to continue benefiting from ecosystem services supplied by biodiversity. The results of this study revealed that 97.5% strongly believed that they had a role to play in conserving biodiversity**.** However, making biodiversity conservation everyone`s responsibility requires a range of measures including legislative reform, improved management of threats, and greater involvement of the community. The results resonate for example with a case done in Coorong, Lower Lakes, and Murray Mouth, where successful biodiversity management and conservation occurred by engaging the indigenous community of Ngarrindjeri (Commonwealth of Australia, 2012). The present findings seem to be consistent with findings of another study (Majalia, 2019), which revealed the elimination of the main causes of forest depletion through the participation of local communities resulting from participatory forest management (Tadesse &Teketay, 2017). The results were to be anticipated, because the respondents in the present project were aware that human activities are causing major changes in biological communities worldwide, and these changes could harm biodiversity and ecosystem functions (see Manu, 2019).

5.6. Perceptions on changes in biodiversity

People in developing countries are more dependent on natural resources than those in developed countries, and this dependence leads to resource depletion and degradation (CFOR, 2001; Heitberg, 2001). The study showed that communities obtained a range of ecosystem services from the site, and human activities were disturbing both the structure

and functions of ecosystems and altering native biodiversity. Results of the study showed that 97.5% strongly agreed to have noticed changes in biodiversity. Respondents indicated that changes in biodiversity were obvious, and this was attributed to the fact that some of the resources they used to collect had declined in quantity, while others were no longer available. Furthermore, they now travelled longer distances when collecting some of the resources, as they were no longer available nearby. As reflected in Table 4.14, the results clearly showed that most of the respondents (97.5%) who took part in the study were, as indicated , highly concerned about changes in biodiversity.

The findings seem to be consistent with other studies, including that of Geretsadik (2016) which found that overexploitation/overharvesting were among the leading causes of biodiversity loss in Ethiopia, while the latter resulted in resource destruction and extinction.

5.7. The importance of forests and forest products

Forests provide a considerable number of ecosystem services, and the loss of these can have significant negative impacts on health and livelihoods, especially among the rural poor, for whom forests are often important safety nets (Wunder, 2001). The results obtained in the present project indicate that all respondents considered forests to be important to their lives. The findings showed that there were three different types of forest products used by the community: medicines, wild fruits, and firewood. With increases in both population and wealth, the demand for products and services from forests and the land on which it grows had also increased. The study showed that different communities collected similar resources including fruits, medicines, firewood.

These findings mirror those of Meijaard *et al*. (2013) regarding people`s perceptions about the importance of forests, in that case in Borneo: the study found that forest use, including use of forest products, were intensive among people in Borneo who lived close to the remaining forests.

5.8. Value-non-consumptive uses of the site

Based on the statistical analysis done in the present study, it is clear 100% of the respondents felt the site was useful to the community. This can likely be attributed to multiple benefits provided by the site. The results of the study indicated that the respondents used the site for four various non-consumptive uses on the levels of culture, religion, sport, and livestock grazing. Livestock keeping is an important economic activity undertaken by households living adjacent to the study site. The study site provided a grazing area for the livestock. As the results indicated, six respondents were involved in livestock farming, ranging in age from 50 to over 60 years.

The findings were consistent with work done by Sohdi *et al*. (2011), who found that people`s perceptions of the importance of forests for health, cultural, spiritual, and environmental were very high in Malaysia. Further extant studies (Sinthumule & Mashau, 2019) showed that indigenous people performed customs and rituals in some of the forests, including the Thathe forest in Limpopo.

5.9. Biodiversity value to traditional healers and herbal medicine conservation

Traditional healers are frequently part of the local community, culture, and tradition. The knowledge and use of medicinal plants are essential for the conservation of cultural traditions, biodiversity, and community health care development in the present and future (Nefhere, 2019). Traditional healers are essential for providing health: their existence and influence on the daily life of rural and urban communities need full recognition (Nefhere, 2019). The findings of the present study indicated that 95% of respondents felt that herbal medicines needed to be conserved due to their importance in the health system. The results of the study indicated that 90% of the respondents agreed that biodiversity was important to traditional healers.

5.10. Perceptions of environmental legislation and its effectiveness.

The globalisation of environmental issues over the past thirty years has brought rapid growth in the number and scope of legal instruments and institutions internationally and locally relating to biodiversity conservation. The results of the present study showed that 25 respondents were aware of the environmental legislation in South Africa whereas 15 were not. This resonated with the educational levels of the respondents, as 17 who knew about this had obtained secondary education while the further 17 had tertiary education. This is an indication that the school syllabus in secondary and tertiary education partly covered the issues of environmental legislation. It seems possible that some of the respondents would have become aware of the legislation through media and newspapers. Municipalities have by-laws, and there is a possibility that, during community engagements, ward councillors sensitised the community about all the bylaws, including environmental legislation and by-laws.

The results of the study indicated that 35% of respondents felt that the legislation was partially effective, while 27.5% indicated that it was not. Some of the respondents indicated that, for the environmental legislation to be fully effective, arrests should be made, and prosecutions carried out for those who contravened that act. The results further indicated challenges around illegal fires, illegal dumping, and destruction of some of the indigenous trees within the Magalies mountain - however, to date, no one has been charged. This could be attributed to the fact that, even though the Magaliesberg mountain had been declared as a biosphere reserve, little implementation of regulations occurs on the ground.

These findings reinforce those of Pender *et al*. (2002), who showed that Ethiopia, despite having designed several important policies and strategies related to environmental protection, nonetheless experienced poor implementation of these, while non-awareness was hindering proper environmental conservation, putting constraints on biodiversity.

5.11. Trade- offs between conservation and land use

It is essential for sustainable land-use management to account for the potential trade-offs among biodiversity conservation, productive land use, and ecosystem services (Fastre *et al*. 2020). Results of the study showed that all different land-use types practiced within the study area were conserving biodiversity. These findings did support extant research (Fastre

et al (2020) that examined the way in which systematic conservation planning and ecosystem service delivery modelling had solved land-use conflicts, while it identified trade-offs between biodiversity conservation and ecosystem services (Fastre *et al*.2020).

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

This final chapter presents the conclusions and recommendations in terms of the objectives of the study, focusing on land-use management and biodiversity conservation.

6.1. CONCLUSION

Conservation of biological diversity is an important objective for sustainable development and livelihood. Given the rising population and urbanisation, more land will be needed to produce food and other essential goods, further impacting biodiversity and ecosystem services. Sustainable land-use management can account for the potential trade-offs between biodiversity conservation, productive land-use, and ecosystem services. There is a need to balance human needs with biodiversity conservation.

To confront the global threats where land-use changes substantially affect and alter ecosystem services, trade-off analysis on ecosystem services concomitant with decisions between land use alternatives need to be the focus of land-use management. To avoid unwanted and possibly irreversible effects of land-use change, sustainable land-use management should assess and manage inherent trade-offs between meeting the site-specific immediate human requirements and maintaining the long-term ecosystem services provisions. The results of the present study revealed that proper land-use management can contribute to biodiversity conservation. The main contributing factor around this was found to be that land-use activities practiced within the area preserve biodiversity for multiple community benefits. Land use practiced within the area included a botanical garden where indigenous medicinal plants are conserved, a large open garden to cater for both cultural and traditional ceremonies comprised of scattered indigenous plants, a bird sanctuary, forest trail, grazing area for livestock, woodland for provision of ecosystem services, as well as open grassland hosting small animals such as porcupines and rabbits. The community enjoyed free access to these benefits and, as a result, they supported the efforts of SLM practices.

The community was supporting biodiversity and ecosystem protection given the multiple values obtained from the site. It was observed that the community was benefiting from both non-consumptive uses on the levels of culture, religion, sporting activities, and livestock grazing, and consumptive ones related to wild fruits, medicines, and firewood. However, the challenge was found to be the way in which to control the quantity of the resources harvested to avoid overharvesting of these, which may lead to their scarcity.

The manager of the site was playing a critical role around promoting biodiversity conservation by allowing a range of groups of people, regardless of their beliefs, to utilise the resources and the site. Further, the area served as a learning centre for different categories of learners - however, the department of education needs to be formally involved by organising camps for school learners to learn about biodiversity focused on indigenous knowledge and land use as, presently, only the manager of the site is engaged. For this site, community support and involvement in conservation efforts can contribute significantly

to preserving biodiversity for present and future generations. As stated, the community valued the site due to all the benefits it offered.

6.2. Recommendations

To achieve a sustainable environment, it is critical to recognise the link between land use and biodiversity, as well as highlighting the effect of a degraded environment on human needs.

The human population is at the centre of every environmental problem and the solution depends on the people of the area. Awareness campaigns should be intensified in the area studied. Departments responsible for the administration of environmental law need to conduct regular awareness-raising of their legislation in the area. This will assist in addressing the problems of illegal fires and dumping, which are ongoing challenges on the site studied. Environmental law, which has been enacted, should be thoroughly enforced. Respondents are aware of the environmental legislation - however, the challenge they mentioned was law enforcement. Law enforcement officials should always be visible in the study site and enforce their legislation where possible.

Overharvesting contributes to biodiversity decline, as is the case within the study site. User groups can assist in resource assessment, which can assist communities to know the best time to harvest resources and, possibly, the quantity users can be allowed to harvest. This might avoid overharvesting of the resources and extinction of other species. Integration of indigenous knowledge with modern conservation approaches is crucial so as to improve and promote local participation in conservation and management of forests. Local knowledge not only provides relevant information on the use of the forest but also contributes valuable information on how to maintain and conserve it.

Communities utilised the site for a range of uses including recreation and leisure, and it is therefore critical that the area be in good condition after use. User groups should also take it upon themselves to look after the area as, presently, only the site manager is responsible for this. The local municipality should supply dustbins for multiple waste disposal and ensure that waste is collected for proper disposal and recycling.

The area has the potential to become an operational learning centre involving learning institutions, the department of education, and other service providers in terms of land use practices that conserve biodiversity within the site as, presently, once more, only the manager facilitates visitors to the site. Developing the area for nature-based tourism activities can improve and diversify the income of local people through creating job opportunities such as tourist guiding services, hiking trails, field guidance for birds and woody species, while various categories of land use practiced within the site make the development of tourist activities possible, including hiking trails. There are several trees of importance that could be labelled for communities and hikers so as to learn their values and use, which can assist in proper conservation and sustainable use. To sum up, there is an integrated need to control biodiversity loss and poverty, conserve and protect natural

resources and the environment for sake of the health of human beings and continue the currently planned sustainable development.

Given this conclusion, future studies could examine the role of indigenous knowledge in a peri-urban area of South Africa, since indigenous knowledge is clearly playing a crucial role in the promotion of health and conservation of biodiversity. Further studies can investigate payment for ecosystem services and land tenure since people are practicing biodiversity conservation despite the challenge of limited land tenure and not receiving any incentives towards this from the government.

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Appendix 1

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences

The aim of the study is to assess the impact of land-use management and biodiversity conservation within and adjacent to the Magalies mountain ridge, in Mamelodi, Tshwane) South Africa. The study serves as an example of better practice in urban biodiversity conservation- namely, including the example of an individual, a traditional leader who is practicing sustainable land use and biodiversity conservation within the area, and supported by the community due to multiple benefits they gain from the site. His indigenous knowledge is crucial in terms of promoting conservation and the trust is conserving resources for public benefits. The indigenous knowledge together with scientific knowledge will assist in capacitating the trust in terms of biodiversity conservation and people will benefit more in terms of resource use and other use within the trust.

CONSENT TO PARTICIPATE IN THIS STUDY

Questionnaire survey for the founder and manager of Mothong African heritage site

REASON FOR CONDUCTING THE STUDY

INFORNATION COVERED WITH THE KEY INFORMANTS

The principal researcher will conduct the interview focusing on the following

Please circle your choice

PART 1: Socio-economic profile

1. Name……

2. Gender Male [1] Female [2]

3. Age 50-59: [1] 60+ [2]

Part 2: Information on the formation about the study site

4. What motivated you to start the Mothong African Heritage site?

5. What do you think can be the role of institution of higher learning in the development of the site to achieve the site objectives?

6. In what way do you think the local government (City of Tshwane), provincial government and national government can assist in site management, development, and biodiversity conservation?

7. What are the main challenges you are facing in your conservation efforts within the area?

Part 3: Importance of biodiversity and biodiversity conservation.

8. Which plants do you use most and for what purposes?

Plant	Portion	use

9. How can you describe the process of land ownership in South Africa?

10. How government can assist individuals who are playing a role in biodiversity conservation**?**

Appendix 2

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences

Mothong Heritage Trust and adjacent site survey questionnaires

Period of survey

Name of surveyor……

Definitions

Individuals at the household level.

These comprises persons ages (18) and over residing in a household.

Non-consumptive use includes the use of the heritage site for other uses besides consumption such as recreation, spiritual, cultural, religious, outdoor.

Resources referred to the products/produce obtained from the forest.

Resource users included persons directly involved with the use of natural resources for their daily business operations from the study site.

The total number of respondents was 40

Section 1: **Demographic Profile**

This section provides personal data on the respondents, and this provides the necessary information on the target group(s) for sensitization as needed

Please circle the correct answer

1. **Name**……

2. **Gender** Male: [1] Female [2]

3. **Age** 18-19 [1] 20-29: [2] 30-39: [3] 40-49: [4] 50-59: [5] 60+ [6]

4. Residential area: Mamelodi township [1] Another township [2]

5. **Residential** Section H C2 [1] Section JC3: [2] Section KC4: [3]

Section GC1: [4] Other [5] Indicate…….

6. **How long** have you been living at your current residential place?

1-10years [1] 11-20years [2] 21-30years [3] 31-40 years [4] 40+ [5]

7. **Occupation**: self-employed [1] unemployed: [2] employed: [3] No response [4]

8. Name of **employer**……

9. **Residential** status: migrant:[1] indigenous:[2]

10. What is the **highest level of** education?

Primary: [1] Secondary:[2] Tertiary: [3] Other [4] No response:[5]

11. Are you involved in any **agricultural** activities? If yes proceed to 12 if No/NR go to 13.

Yes:[1] No: [2] No response [3

12. What **areas** in agriculture/farming are you involved in?

Crop production: [1] Livestock: [2] No response: [3]

Section 2: Knowledge on relationship between land-use and biodiversity

13. Have you **heard** of the word biodiversity? If yes proceed to 14 if No/Neither of the two go to 15

Yes:[1] No [2] No response [3

14. Where did you hear the term?

Schooling [1] Media [2] Organized events [3] Neither of the above [4]

15. What do you understand by the term biodiversity?

16. Have you participated in any discussion on biodiversity?

Yes [1] No [2] No response [3]

17. Have you heard of the term land use?

Yes [1] No [2] No response [3] If yes proceed to 18 if No/NR proceed to19

18. Where did you hear the term?

Schooling [1] Media [2] Organized events [3] Neither of the above [4]

19. What do you understand by the term land use?

20. Have you participated in any discussion on land use?

Yes [1] No [2] No response [3]

21. Do you think there is any relationship between land

use and biodiversity? Strongly agree [1] Strongly disagree

[2] Neither agree or disagree [3]

22. What do you is the relationship between biodiversity and land use?

Section 3: Knowledge on biodiversity conservation.

23. Do you think biodiversity is under threat?

Strongly agree [1] strongly disagree [2] Neither agree or disagree [3]

24. Do you think you have a role to play in biodiversity conservation? Strongly agree [1] Agree [2] Disagree [3] Strongly disagree [4] Neither agree

or disagree [5]

25. Have you noticed any change(s) with regard to biodiversity in the last 20 years on the entire planet including South Africa? If yes proceed to 26 if no/NR proceed to27

Yes [1] No [2] No response [3]

26. How do you feel about the changes?

Worried: [1] Not worried: [2] No response [3]

27. How do you think biodiversity can be

conserved/ biodiversity loss can be reduced?

28. What do you think is the role of local government, provincial department in biodiversity conservation?

29. How government can assist individuals who are playing a role in biodiversity conservation?

30**.** What are the main challenges of biodiversity conservation within South

Africa?

31**.** How can traditional and western medicinal practitioners do to conserve biodiversity?

32. In your view whose responsibility is the conservation of biodiversity?

33. What is your role in reducing biodiversity loss/ decline?

34. A u aware of environmental legislations responsible for biodiversity conservation? If yes proceed to 35 if No/NR proceed to 36.

Yes [1] No [2] No response [3]

35. How do you rate those policies and legislations in their role concerning biodiversity management and conservation?

Fully effective [1] Partially effective [2] Not effective [3] No response [4]

Section 4: Use of the study site

36**.** How long have you know the site?

1-5 Years [1] 6-10 years [2] 11-15 years [3] 16- 20 Years [4] 20+ [5]

37. Do you think the heritage site is beneficial to the community of Mamelodi?

Yes [1] No [2] No response [3] If yes proceed to 38 if No/NR proceed to

39.

38. Why do you think is important?

39. Do you use site for non-consumption gains/use? If yes proceed to 40 if not proceed to 42

Yes [1] No [2] No response [3]

40. Indicate the non-consumptive uses in the heritage site

Cultural activities [1] Religious/Spiritual activities [2] Sporting activities [3] Livestock [4] Neither of the above [5]

41. Is there any fee payable when using the site?

No fee payable [1]

Fee payable [2]

Other [3]

42. Is biodiversity important to the traditional healers?

Yes [1] No [2] No response [3]

Use of resources within the study site

43. Are you or your family members involved in any activities that involved utilization of resources extracted from the site and adjacent areas? If yes, proceed to 44 if No/No response proceed to 46

Yes [1] No [2] No response

44. If yes how do you access the site for resources?

Free access [1] Access with a fee [2] No response [3]

45. What are the common uses of forest products/produce?

Medicines [1] Wild fruits [2] Firewood [3] Grass [4 No response [5]

46. Do you use herbal medicines? If yes, proceed to 47 if No/NR proceed to 50

Yes [1] No [2] No response [3]

47. Which plants do you use and for what purpose?

plant	use

48. Do you think the herbal medicines should be protected?

Yes [1] No [2] No response [3]

49. Common local practices that promote conservation?

50. What do you think are the role of biodiversity to urban/ township people?

51. Do you think forests are important? If yes, proceed to 52

Yes [1] No [2] No response [3]

52. Why do you think forests are important?

Appendix 3

Pictures of various species that grow on the mountain ridge provide benefits to the community residing within the study area and those living adjacent to the study site

Englerophytum magalismontanum

Vangueria infausta

Ochna pulchra

Burkea Africana

Strychnos spinosa

Xerophyta retinervis

Lopholaena coriifolia

Stem domination of *Ochna pulchra*

Jacaranda mimosifolia (green arrow)

Lantana camara

Appendix 4

MSC IN ENVIRONMENT AND SOCIETY

Assessing the impact of land-use management and biodiversity conservation within and adjacent to the Magalies mountain ridge, in Tshwane (South Africa).

Nevhufumba Lufuno

Student No 29444455

Supervisor: Prof, Emma Archer

University of Pretoria

Participants briefing and consent letter

Dear participants

I am Mr. Nevhufumba Lufuno, and I am collecting data from you, which will be used, in my dissertation for the impact of land-use management and biodiversity conservation in and around the Mothong African Heritage site for the University of Pretoria.

The objective of the dissertation research will be to evaluate the impacts of land use on biodiversity in the study area and the information you will be asked to provide will be used to provide insights to achieve this objective.

The data you provide will be used for the dissertation and will not be disclosed to any third party, except as part of the dissertation findings, or as part of the supervisory assessment process of the University of Pretoria.

The data you provide will be kept by the university so that it is available for scrutiny by the University of Pretoria as part of the assessment process. If you feel uncomfortable with any of the questions being asked, you may decline to answer such specific questions. You may also withdraw from the study completely, and your answers will not be used.

If you decide to withdraw from the study, please call me on 0829076118 or write to me at Lufuno.vhufumba@gmail.com.

The researcher

Nevhufumba Lufuno

I have read and understood the contents of this briefing form, and freely and voluntarily agree to participate in this research. I am happy to be identified as a participant in the research.

Signed Date

…… …….