ECOLOGICAL IMPLICATIONS OF LAND USE / LAND COVER CHANGES IN THE MARGUBA RANGE OF OLD OYO NATIONAL PARK, NIGERIA

By

Adetomi Olamide ADEKOYA
B.Sc. Plant Biology (Ilorin), M.Sc. Environmental Biology (Ibadan).
Matriculation Number: 180788

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CERTIFICATION

I certify that this research work was carried out by Miss. Adetomi Olamide Adekoya in the Department of Crop Protection and Environmental Biology, Faculty of Agriculture, University of Ibadan, Ibadan, Nigeria.

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Supervisor

O. S. Olubode

B.Sc. (Hons.), M.Sc., Ph.D. (Ibadan), Plant Ecologist,

Senior lecturer, Department of Crop Protection and Environmental Biology,

University of Ibadan, Ibadan, Nigeria.

DEDICATION

I dedicate this work to God almighty, the giver of life, wisdom, knowledge and understanding, who reigns and owns all.

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ABSTRACT

Protected Areas (PAs) such as Old Oyo National Park (OONP) are created to conserve biodiversity. In Nigeria, unregulated anthropogenic activities in PAs cause changes in Land Use/Land Cover (LU/LC) thereby, disrupting their ecological functions. Although, surveys have been conducted to assess forest resources in Marguba Range (MR) of OONP, effects of changes in LU/LC in MR have not been adequately documented. Therefore, flora diversity and shift, Carbon Stock (CS), LU/LC Changes (LU/LCC) and their ecological implications in MR of OONP were investigated.

Buffer Zone (BZ-1.44 ha) and Core Zone (CZ-2.88 ha) of the MR were studied from 2017 to 2019 in two consecutive Dry Seasons (DS) and Wet Seasons (WS). Five hundred and forty quadrats (BZ-180; CZ-360) were laid in 108 plots (BZ-36; CZ-72) on 36 perpendicular transects (BZ-12; CZ-24) along three baseline transects (BZ-1; CZ-2) to assess flora composition and diversity in Standing Vegetation (SV) following systematic sampling procedures. Soil samples were collected at 0-15 cm depth from five points within each plot and bulked to assess Soil Seed Bank (SSB) composition and diversity following standard procedures. The CS was estimated using non-destructive allometric equation. The LU/LCC (ha/year) was evaluated with GIS and remote sensing techniques on Landsat imageries of 1990, 2000, 2010 and 2019. Supervised image classification was used to identify the LU/LC classes. Data were analysed using descriptive statistics, Relative Importance Value (RIV, %), diversity indices, and Jaccard similarity index (%).

Standing vegetation composition of individuals/ha, families and species were BZ: 2,305, 6 and 12 (DS), 6,613, 25 and 70 (WS); CZ: 2,523, 6 and 11 (DS), 8,493, 24 and 73 (WS), respectively. The SSB composition of individuals/ha, families and species were BZ: 741, 15 and 30 (DS), 452, 13 and 27 (WS); CZ: 330, 16 and 34 (DS), 171, 14, 27 (WS), respectively. Most prevalent floras as indicated by RIV were *Chromolaena odorata*: 12.2 (BZ); 13.3 (CZ) and *Aspilia bussei*: 6.9 (BZ); 8.2 (CZ). More species were present in the SSB in DS: 370.5/ha (BZ); 165.0/ha (CZ) than WS: 226.0/ha (BZ); 85.5/ha (CZ). Dominance and Shannon-Wiener were: 0.31 and 1.58 (DS); 0.07 and 3.25 (WS) in BZ; 0.26 and 1.64 (DS); 0.07 and 3.18 (WS) in CZ, for herbaceous species, respectively. For trees, Dominance and Shannon-Wiener were 0.07 and 3.13 in CZ; while BZ had 0.06 and 3.02, respectively. The SV and SSB compositions had low similarity with 22.7 (DS) and 7.9 (WS). Carbon stock was 3.41 t C/ha (BZ) and 7.53 t C/ha (CZ). The LU/LCC showed that bare surface and forest land use types gained 543.10 and 122.41, respectively, while shrublands lost 724.83.

There was a shift in species composition of standing vegetation and soil seed bank in Marguba Range. Invasion by *Aspilia bussei* caused ecological erosion of native species. Carbon stock of 7.53 t C/ha from woody species was adequate for a woodland savanna ecosystem. Changes in land use degraded the land cover, thereby threatening ecological functions of Marguba Range of Old Oyo National Park.

Keywords: Marguba Range, Ecological shift, Land use classifications, Flora diversity, Carbon stock

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LIST OF ABBREVIATIONS

PAs	Protected Areas
NPs	National Parks
OONP	Old Oyo National Park
LULC	Land use and Land cover
LULCC	Land use and Land cover changes
ES	Ecosystem Services
IUCN	International Union for Conservation of Nature
PAM	Plant Available Moisture
PAN	Plant Available Nutrient
WTO	World Tourism Organisation
CO_2	Carbondioxide
KMTNC	King Mahendra Trust for Nature Conservation
LFC	Linking Tourism Conservation
CZ	Core Zone
BZ	Buffer Zone
SV	Standing Vegetation
SSB	Soil Seed Bank
FAO	Food and Agriculture Organisation
ITPS	Intergovernmental Technical Panel on Soils
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
GIS	Geographical Information System
RS	Remote Sensing
NDVI	Normalised Difference Vegetation Index
USGCRP	United States Global Change Research Program
USGS-EE	United States Geological Survey Earth Explorer
C	Carbon
DBH	Diameter at Breast Height
AGB	Aboveground Biomass
UNFCCC	United Nations Framework Convention on Climate Change
IPCC	Intergovernmental Panel on Climate Change
LGA	Local Government Area

IDI	In-Depth Interview
SPSS	Statistical Package for Social Sciences
ENVI	Environment for Visualizing Images
ROI	Return on Investment
LANDSAT	Land Satellite
GPS	Global Positioning System
GBH	Girth at Breast Height
PAST	Paleontological Statistics
DECORANA	Detrended Correspondence Analysis
TWINSPAN	Two-way Indicator Species Analysis

CHAPTER ONE

INTRODUCTION

National Parks are protected areas in natural ecosystems specifically designated by governments for the conservation of natural resources. This aim is achieved by managing, protecting and monitoring such areas against human interferences, such as farming, poaching and grazing competition, thus increasing the population of naturally resident wild animals and plants (Adewumi *et al*., 2019). National Parks are in-situ forms of conservation which are important for achieving sustainable quality of living for wildlife and plants in their natural ecosystem (Boon *et al*., 2012). They contribute to normal functioning of the ecosystem by preserving biodiversity while ensuring that the requirements of the hosting local communities are met (Naidoo *et al*., 2019). Biodiversity conservation is increasingly becoming dependent on protected areas (Paiva *et al*., 2015) and a successful solution to ensuring ecosystem protection (Lewis *et al*., 2017). Protected areas store about 15% of the terrestrial carbon stock with vast biological components including trees and soils (Ferraro *et al*., 2015).

Land use is the act of using or exploiting land area such as bare-land, grassland, arable cropland, wetlands, while a change in these activities is referred to as land use change (Verburg *et al*., 2015). Land use/Land cover change (LULCC) causes the most important human-made effects and natural disorder to the environment and eventually leads to biodiversity erosion. Hence, Land use/Land cover change is a reliable indicator of ecosystem disturbance and global change processes (Nanda *et al*., 2014; Fetene *et al*., 2019). Geographical Information System (GIS) technologies offer the opportunity to understand the implications of LULC changes in an ecosystem (Kafi *et al*., 2014) by investigating/ monitoring how land uses are distributed among ecologically defined entities such as watersheds, National parks, and thus allows for management goals to become easily focused. One of the prerequisites for better use of land is information on the existing LULCC pattern through time. Geographical Information System and Remote Sensing (RS) are well established information technologies whose application in land and natural resource management are now widely recognized (Kafi *et al*., 2014).

The wide recognition is due to the fact that they offer the opportunity to understand the implication of LULCC on an ecosystem. GIS and RS, however, are fundamentally different technologies, and practitioners still consider themselves to be mainly concerned with using one or the other (Kafi *et al*., 2014). Owing to this fact, Zhu (1997) reported that the understanding of spatiotemporal land cover systems is essential for effective natural resource management, forecasting, and assessment using GIS and RS.

Seed banks play essential roles in the regeneration of tropical forests (Taiwo *et al*., 2018). Soil seed banks are formed when plants disperse their seeds in the soil and preserve them through by plants to use germination inhibitors to suppress germination under unfavourable soil and environmental circumstances (Saatkamp *et al*., 2014). The Soil seed bank has a significant impact on plant regeneration in disturbed ecosystems and offsets the unavailability of seed sources in degraded areas.

Although National Parks were created mainly for biodiversity conservation, many National Parks have recorded failure in this regard with conflicts occurring between local people and Park management due to restrictions imposed on use of resources (von Ruschkowski, 2010). Global diversity is decreasing at an alarming rate and tropical forests are faced with problems of deforestation, grazing, land clearing for agriculture (Hosonuma *et al*., 2012). These are detrimental to biodiversity and eventually cause loss of ecosystem services. The implication is that ecological processes and support provided by the environment which are essential to human well-being are interrupted by this global loss of diversity (Butchart *et al.*, 2015).

Exploitation of forest resources has been at the expense of natural water and climate regulation and has replaced some people's subsistence and cultural values and put them at risk. Also, threats such as land use/land-cover change, in addition to their projected influence on biodiversity, have a synergistic effect that cannot be neglected because they are the key drivers to biodiversity loss (Mantyka-Pringle *et al.*, 2015). Some studies have combined biodiversity indices with socioeconomic and environmental scenarios to help create policies that will help the world achieve its sustainability goals (Lambin *et al.*, 2003; Arturo *et al*., 2015). Since they have an effect on vital components of our natural resource capital, such as water resources, vegetation, and biological diversity (Sembosi, 2019). Environmental monitoring and management, require precise and appropriate information to achieve sustainable usage of protected areas. The collection of adequate and updated information regarding the environment and how much it continues to evolve is insufficient in many developing countries, particularly Nigeria (Lambin *et al.*, 2014). While the functioning of the environment is important to maintain carbon sequestration levels (Djomo *et al*., 2016), it often relies on mediating variables such as the availability of resources. Hence, there is a necessity for precise methods to estimate the substantial carbon stored in tropical ecosystems to ascertain carbon sequestration potential of such ecosystems (Djomo *et al*., 2016).

With disturbance caused by grazing, and conversion of land to agriculture around National Parks, species invasion may be promoted to influence the community structure of native diversity, hence loss of important species. Understanding the community structure of species and implications of seed bank for natural regeneration is expedient, whilst accounting for the contribution of National Parks to carbon sequestration. Only a few research has looked at the regeneration capacity of seed banks in savanna protected areas in Nigeria.

There is therefore need to explore the seed banks of savanna lands to encourage in the establishment of desirable vegetation particularly in the Parks. The relationship between soil seed bank and vegetation composition is important to understanding the changes in community structures and development of strategies for restoring vegetation (Kassahun *et al.,* 2009). Soil seed banks are essential in the preservation of biodiversity in National Parks (Taiwo *et al*., 2018). The extent of diversity of soil seed bank is necessary to assess and develop conservation strategies (Zaghloul, 2008), as their contribution to the potential composition of plant communities is essential while preserving native plant communities. In a bid to conserve biodiversity and preserve them in nature, it is important that natural systems and anthropogenic contribution to their loss are checked, and the proper management plans are put in place.

The goal of this research is to understand the ecological relationship that exists among selected ecological components of natural communities in the Marguba Range of Old Oyo National Park in the face of reported anthropogenic incursions into protected areas in Nigeria.

The objectives of the study are to:

- Investigate the perception of local people on the impact of land cover changes on Marguba Range of Old Oyo National Park, Nigeria
- Assess the past and current land use and land-cover of Buffer and Core zones of Marguba Range of Old Oyo National Park, Nigeria

- Assess and compare the phytosociological attributes of the Buffer and Core zones of the Marguba Range of Old Oyo National Park, Nigeria
- Investigate the contribution of the soil seed bank of the Buffer and Core zones of the Marguba Range of Old Oyo National Park to management and conservation of flora
- Evaluate the current contribution of the land cover of the Buffer and Core zones of the Marguba Range of Old Oyo National Park, Nigeria to Carbon sequestration

CHAPTER TWO
LITERATURE REVIEW

2.1 Protected areas

Protected areas (PAs) are critical for preserving biological diversity in the wild and its creation is inclusive of the most significant conservation approaches accessible to communities (Lewis *et al.*, 2017). These areas have been established for protection of biodiversity and they occupy 10% land area of the planet (Paiva *et al*., 2015). The PAs are crucial for plant and animal maintenance, yet their isolation in agriculturally inclined landscapes is increasing (Scriven *et al.*, 2015). Natural habitat conversion to other land use types is frequent in tropical regions today, and the PAs are particularly responsible for preserving high levels of biological diversity (Laurance *et al.*, 2012; Scriven *et al.*, 2015; Sembosi, 2019).

The problem human and the environment in general face is climate change and it drives geographical shifts in spectrum of flora and fauna (Thomas *et al.*, 2012). Rainfall, temperature, and precipitation cause several shifts, and species' capacity to change range is constrained by the availability and spread of habitat that are suitable (Feeley and Silman, 2010; Sembosi, 2019), species that do not shift their range, on the other hand, may be prone to a higher risk of total loss (Thomas *et al.*, 2012). Around several protected areas, intensive land usage has recently increased, according to a variety of reports (Gimmi *et al.*, 2011), because of this, we are unable to organise them as distinct, entities that do not change (Bengtsson *et al.*, 2003). Palomo *et al.* (2013) emphasised the increased attention provided by policy makers that deal with ecosystem services which is the primary purpose of PAs as regards their effectiveness in conservation of biodiversity.

The survival of the creatures and biological processes observed within most protected areas depends on connections with neighbouring territories (Hansen *et al.*, 2011; Visconsti *et al*., 2019). All conservation goals cannot be met by only protected area, even though they are the most effective global conservation strategies; therefore, there has been increasing attention to conservation values of buffering lands around areas that are protected (Hansen and Defries, 2007; Hansen *et al*., 2011; Gimmi *et al*., 2011). Influence of long-standing institutions land around PAs and its success has drawn the attention of researchers. Gaston *et al.* (2008) reported that protected areas' functions in capturing biodiversity and mitigating the detrimental impacts of external influences on biodiversity. However, Curran *et al.* (2004) reported the effects of forestry as external factors that erode the effectiveness of protected areas likewise urbanisation (Wade and Theobald, 2010; Sembosi, 2019).

Protected areas have a significant impact on conservation of wild endangered flora and fauna. But, nowadays, there has been a global, regional and local decline in wildlife habitats and population (Nolte *et al*., 2013). This, according to Sala *et al.* (2009), is due to changes in land usage, encroachment of human into wildlife territories, human-wildlife conflicts (Mekonen, 2020), recurrent droughts, poaching and other anthropogenic activities. Chape *et al*. (2005) stipulated that data collected from protected areas on environment and species density can serve as a foundation for detecting gaps in biodiversity conservation, which informs decision-makers and partners about conservation objectives.

Today most endangered and highly biodiverse populated species and habitats in West Africa are contained in protected areas (Mekonen, 2020). In the region a total of 1,936 nationally protected areas, currently covering about 9.6% of western Africa, have been identified. About 90 per cent of these protected areas are small and dominated by forest reserves. Furthermore, 53 protected areas have been designated internationally, including 17 Biosphere Reserves. The size of the protected areas varies widely, usually ranging from less than 1 sq km to 97,300 sq km. Large protected areas, especially site clusters, are, however, essential for sustaining bigger species populations and guaranteeing fully functioning, adaptive ecosystems (Hansen and Defries, 2007; Mallon *et al*., 2015).

2.1.1 Protected areas and ecosystem functions

Primary food production, biogeochemical cycles, and disintegration are examples of ecological processes that regulate energy, nutrient, and organic matter flows via an environment. Plants employ sunlight to convert inorganic materials into newer plant molecules, capturing, releasing, and recapturing necessary nutrients while breaking down and recycling organic waste. A recent meta-analysis shows that vegetation debris variety improves breakdown and regeneration of components when organisms die, which is corroborated by subsequent research (Cardinale *et al*., 2011).

The consistency of biodiversity suggests that there are fundamental values that govern how community organisation affects ecosystem functioning. Although, this report is exempted for some ecosystem and processes (Cardinale *et al*., 2011).

Conservation of biodiversity in PAs has been the mainstay of protection efforts for so long (Lewis *et al*., 2017). The capacity of PAs to ensure the protracted allocation and provisioning of ecosystem services (ES) is gaining traction, these are the advantages that people obtain from the ecosystem (Visconti *et al*., 2019).

Other worldwide stresses (e.g., changing climate) and loss of diversity which have already garnered major governmental attention may have a statistically substantial impact on ecosystem services and functions (Houghton *et al.*, 2007). Benefits provided by PAs includes food provision/availability and means of livelihood for local communities (Ivanic *et al*., 2017), storage of carbon (Ferraro *et al*., 2015), fresh water (Harrison *et al*., 2016) especially in countries that are developing (Naidoo *et al*., 2019). The significance and success of protected areas cannot be overstated as natural reservoirs for biological diversity of species that are agriculturally valuable such as pollinators, wild crop relatives, and pest control. Stolton and Dudley (2010) reported Karacadag Mountain in Turkey as a place where crop relatives that may be critical for crop breeding are being protected. West Tien Shan in central Asia is a protected area that harbours walnut forests and other wild relatives of fruit trees such as pears and apples (Mackinnon *et al.*, 2005). The significance of other metrics, inclusive of portrayal of the environment and the state of critical biodiversity aspects (Visconti *et al*., 2019). Also, protected areas situated on drylands have been known to help introduce land management activities that minimize land loss while also protecting some of the world's greatest wildlife spectacles (Nolte *et al*., 2013; World Bank, 2017). Although, Butchart *et al*. (2015) stated that PAs in many countries lacks the adequacy to prioritize areas for conservation of biodiversity, even if the target of global PAs are met, they will fall short of achieving adequate ecosystem's and biodiversity's services (Nolte *et al*., 2013; Butchart *et al*., 2015).

2.1.1.1 Protected areas' effectiveness in achieving conservation objectives

Protected areas are commonly formed in environmentally sensitive locations where lands are less fertile for agricultural purposes (Venter *et al.,* 2018) or where there are no competing land uses (Joppa and Pfaff, 2009). Despite the fact that this technique may allow governments to reach protected area targets by 2025 (protection of 25%), studies have shown that it is unlikely to effectively safeguard areas that provide direct benefits to people (Naidoo *et al*., 2019; Mitchell *et al*., 2021). This is particularly true for ecological services like freshwater and leisure, where human demand and access are critical to achieving service benefits. In such a time when the global relationship with nature is fading, guaranteeing how an ever-increasing urbanization derives from and appreciates nature promotes the values of conservation strategy (Soga and Gaston 2016). The threat to protected area has been at an alarming rate and very severe all over the world, particularly in the tropical ecosystems (Carey *et al.,* 2000; Bruner *et al.,* 2001; World Bank, 2017). Nigeria's natural ecosystems are particularly sensitive to a variety of deliberate and unintentional negative effects (Marguba, 2002). Carey *et al*. (2000) listed the following risks to protected areas in ascending level of importance:

- Without affecting the general structure of the protected area, resources can be extracted (e. g. hunting of animals used as bush meat, exotic plants used in medicine or for construction or exploitation of a particular type of fish).
- The environment of the protected area has been completely devastated (for example, by invasion, lengthy air quality degradation, or ongoing hunting impact).
- Overexploitation and eventual damage by removing forest cover, constructing roads across protected areas, establishing communities in protected regions, or mineral extraction.
- Isolation of protected area through large buffering land conversions that were designed to act as a barrier for the Park's protection.

On average, 43 percent of most important bird and biological diversity sensitive regions are protected globally (Donald *et al*., 2019b). In Colombia, PAs overlap with key regions for vulnerable species, biological processes, ecosystem quality, aesthetics, and availability of water at low to intermediate levels (3–56%), with provision of water being the least adequately protected (Garcia Márquez *et al*., 2016). PAs, for example, cover 15.1 percent of China's land area, accounting for 8.5–17.9 percent of vulnerable species ranges for various taxonomical groups and 10.2–12.5 percent of key services rendered by the ecosystem (preservation of water and soil, prevents dust storm, and sequesters carbon) (Xu *et al*., 2017). As a result, more work needs to be done to protect biological diversity and assure the long-standing availability of nature's profits to humans.

2.1.2 National Parks (NPs) in Nigeria

National Park is a designated area of land set aside, owned, and operated by the federal government for the purpose of conservation, preservation, and protection of biodiversity for recreational, educational and scientific purposes**.** Nigeria is blessed with a unique and rich array of ecosystems and variety of fauna and flora. National Park in its aim to conserve the rich biodiversity in Nigeria is thriving, but humans are the most dangerous cause of destruction to this biodiversity. Habitat loss is the major cause of biodiversity loss which is caused by pollution, Global warming, deforestation, overpopulation. IUCN estimated that about one third of all known species are threatened with extinction and other experts noted that by 2050, around 30% of all species on the planet will be lost/extinct. The importance of biodiversity is well established in West Africa. The diverse ecosystems provide habitat for more than 2, 000 species of amphibians, birds, and mammals from dry savannah to tropical forests (IUCN, 2015). Therefore, subsequent and prompt check should be incorporated into the management system of biodiversity for easy check and balance of the cause and effect of loss.

Nigeria is rich in ecotourism opportunities, such as unique/diversified culture, biodiversity, and beautiful/stunning landscapes. In Nigeria, there are few communities without unique/distinct ecotourism attractions, heritage, food, history and environment (Ijeomah and Eniang, 2018). Kainji Lake National Park, Cross River National Park, Gashaka Gumti National Park, Kamuku National Park, Chad Basin National Park, Old Oyo, and Okomu National Park are among the seven national parks in Nigeria that houses a varied range of wildlife species. Meanwhile, Yankari National Park has been downgraded to a game reserve. Apart from National Parks, ecotourism centres are also identified and they include but are not limited to forest reserves, game reserves, waterfalls, beaches, resort centres, mountains etc.

The Old Oyo National Park (OONP) is the fourth major Park covering an area of 2512 km^2 in Nigeria, in the northern section of Oyo, it shares its borders with the states of Kwara and Oyo. It houses various diversity of plant and animals, making it unique among Nigerian parks as a historical tourism attraction with many facets (Adedoyin *et al.*, 2018).

Southern Guinea Savanna is the vegetation type found in the OONP (Keay, 1959). The southern section of the vegetation, however, was categorized as Forest savanna by Charter (1970), based on a more thorough study as Mosaic of wooded savanna with relics of moist semi-deciduous woodland, moving northwards towards drier savanna conditions, a Leguminous wooded savanna with a persistent covering of annual grasses at the base. The vegetation was divided into four categories: thick woodland and forest outliers in the south and north west, outcrop vegetation in steep and rocky regions, mixed open savanna in the centre and north east, and riparian grassland and bordering woodland and forest along important rivers and streams (Geerling, 1973). A group of specialists working on the OONP identified and recognized forest and dense savanna mosaic woodland of the park around Sepeteri axis as site A, dense and open savanna woodland mosaic in the central portion of the park as zone B, dense and open savanna woodland mosaic north of Igbeti - Kishi axis as zone C, and open savanna woodland in the north-east of the park (Oyo-Ile sector) as zone D (Afolayan *et al*., 1997).

2.1.2.1 Savanna

Savanna is an intermediate ecosystem between forest and deserts which is home to numerous desert and forest species. Savanna results from the processes of desertification, deforestation and extinction (Campbell, 2013). Savanna is a tropics vegetation type in which woody plants and grasses have a considerable influence on biogeochemical cycles such as nutrient cycling, hydrology, and primary production, as defined by Scholes (1990). It is the most common landscape unit in tropical areas as it designates typical tropical grassland with scattered trees (Rogers, 2003). Savannas span over 50 percent of the African continent, surrounding complex habitats with an extensive variety of woody vegetation, from Miombo woodlands which have densely wooded to sparse trees in the Serengeti grassland. They are distinguished climatically (seasonality of water availability) and structurally (wood/grass composition) (Christin and Osborne, 2014), grasses compete with seedlings of tree for moisture, nutrient and sunlight (Vadigi and Wards, 2013). There are five main ecological factors: plant available moisture (PAM), Plant available nutrient (PAN), fire, herbivores, human activities (Stott, 1994). The fire, herbivores and human activities are secondary modifier while PAM and PAN are involved in primary production. However, PAM is more important than PAN because moisture (from rainfall, ground water and irrigation) affect nutrient availability in the soil and later release for plants uptake. This phenomenon is popularly associated with savanna ecosystems. In grass-dominated ecosystems, herbivory and burning affect structure of plant communities, nonetheless, these perturbation patterns are changing all across the planet (Koerner *et al*., 2014).

2.1.2.2 Anthropogenic influence of Savanna formation and maintenance

Savanna biome contains varied endemic flora and fauna, inclusive of fascinating mega-fauna that are vital to poaching and wildlife tourism, and provide several hundred millions of dollars to Africa's economy (World Tourism Organization, 2015). Apart from these attributes, popular reliance on an extensive variety of products and services rendered by the savanna ecosystem across the continent is alarming. Water and food provision, herbal medications, animal browsing, construction with lumber and grass, fuelwood and charcoal are examples of these services (Ryan *et al*., 2016). Four human drivers induced fast vegetation shifts over African savannas throughout the Anthropocene, endangering biodiversity and ecosystem services as people eventually took control of the Earth system. Change in land cover, anthropogenic changes to fire, browsing managements, climate change, and rising CO2 levels in the atmosphere, among others (Malhi, 2017). While such disturbances might encourage ecological variety and high numbers of woody species, they also have the potential to harm this ecosystem beyond a specific threshold, the severity of these abnormalities may become more severe (Koerner *et al*., 2014) as well as having a detrimental influence on the growth and development of woody plants, resulting in forest degradation and the extinction of big trees (Fetene *et al*., 2019). The vegetation cover of the earth has been transformed by humans successfully through fire, grazing by livestock and deforestation. However, deforestation is the greatest damage humans have done to the earth surface causing transformation or modification of savanna biomes (Matschullat, 2014). If the current rate of deforestation continues, habitat destruction of the savanna will result in huge loss of biological diversity and its carbon counterpart throughout the world (Estes *et al*., 2016). Woody plant development and death could be directly affected by rising temperatures and shifting rainfall patterns (Khaine and Woo, 2014), by disrupting fire regimes, and indirectly affecting tree cover (Andela and van der Werf, 2014).

2.1.2.3 Buffer zone and its functions

Buffer zones are demarcated from the boundaries of the NPs and the implications is that people have to relinquish or forfeit their traditional right of making use of the park's resoures (King Mahendra Trust for Nature conservation, 2005). Ogogo *et al.* (2010) documented that through establishment of buffer zone, majority of people considered it as stopping them from having access to their traditional heritage and felt more aggrieved that this situation has been extended. There have been postulations that the people should be carried along in the management of the NPs. A larger percentage of the people perceived the buffer zone project as a bad project and they are likely to fault the laws establishing it, which will expose the buffer zone to abuse in terms of resource extraction (Ogogo *et al.*, 2010).

This was the case some years back at Old Oyo National Park when the people came with several arms with forceful access into the park, wounded some of the park guards and extracted resources of their choice before they were controlled. People who have their farmlands close to the buffer zone were coming close and were inside the buffer zone before the managements of the park had to send them packing and stopped farming activities within the buffer zone. Ebin (2001) also supported the fact that illegal activities have been on the increase in the buffer zone and the core of the park. Adedoyin *et al*. (2018), who focused on the undermanagement of buffer zones surrounding Nigeria protected areas, backed up this report. In practice, the intention of a buffer zone is to simultaneously alleviate the pressures from human growth on protected areas and to fulfil the population's social and economic needs that are affected (Justin *et al.,* 2017) by serving as borders and additional layer to protect the core of the park from human encroachment and extraction of resources.

2.1.2.4 Core zone and natural resources

Core zones are the intrinsically protected area of the park where biodiversity is preserved which disallow entry by people and their sole right of extraction. This area is restricted to human entrance; therefore, extraction of resources is not allowed in this zone. Usually, information from this zone is used for the evaluation of the maintenance of environmental quality and sustainability of activities in surrounding areas e. g. Buffer zone, transition zones. Once there is resource depletion in the core area, then the National Park is at risk of human encroachment and climate change effects. Tourist activities was banned in the core area of most reserves in India to control the disturbance of animals, with tourist seen as more of a problem than positive factor (L. F. C., 2019).

2.1.3 People's perception of the park, its conflicts and agreement

The establishment of National Parks (NPs) has generated tensions between park management and local citizens, as it was known in the first western concept of PAs (Chape *et al*., 2005). The primary motivation for the establishment of Parks is not far-fetched and is for the protection and conservation of natural resources, ability to keep wildlife in their natural states as well as serving the local community around it (Mojo, 2020). However, livelihoods of humans are threatened when their access into the park for available resources is restricted (Allendorf *et al.,* 2012) which is seen as a form of human harassment and therefore results in negative sentiments towards PAs in Nepal. One of the problems conservations faces in Nigeria is the conflict between conservation and the objectives of the local people. Resource extraction was considered to be a taboo for the people who gave up their position to use their lands and resources for the benefit of a protected area (KMTNC, 2005). This was also reported by Allendorf (2012) that the right of communities surrounding a protected area is forfeited for exploitation of biodiversity which later reflected in their reaction to the discriminating government policies. Although their attitude was supposed to change for the ultimate aim of conservation and change of their human behaviour towards it, yet humans do not care about how copious biodiversity to protect but how much they need to exploit it (Soga and Gaston, 2016).

This problem is a huge conservation barrier, and it's only becoming worse as a result of an unprecedented increase in population of humans, global warming and change in climate, and other anthropogenic impacts, which are all placing excessive pressure on scarce natural resources (Mitchell *et al*., 2021). Therefore, it is expedient that human behaviour and attitude towards conservation is changed (Margoluis *et al.*, 2009). How humans perceive an issue is therefore one of the most important reasons that influences how they respond to the matter (Chen *et al.*, 2011; Mojo, 2020). Perception is considered as a way people interprets a subject matter not necessarily understanding it to produce meaning, and this is dependent on their interest, experiential knowledge (Bennett, 2016; Long *et al*., 2020) and social status.

Sometimes, peer pressure makes people behave in a certain kind of way and towards conservation issues. Humans might not want to be condemned or reprimanded by others; therefore, they exhibit some kind of positive attitude towards conflict management or using a peer as a point of reference, they establish their own belief system and values (Chen *et al*., 2011). Perception ultimately shapes people's actions and therefore may result in conflicts of interests or decision (Tessema *et al*., 2010). Whether they are true or false, reasonable or not, how people perceive an issue influence the decisions they make, which are penultimate for sustainability of conservation activities (Bennett, 2016). However, limiting their activities or restricting their entrance into protected areas have created long-term conflicts between conservation managers and communities (Tessema *et al.*, 2010; Pullin *et al*., 2013). Studies have shown that perception aimed at conservation are shaped by several factors (Kideghesho *et al.*, 2007) which includes demographic factors (gender, educational levels, age, household size) (Mutanga *et al.*, 2015) as well as benefits accrued from PAs. Past experiences and relationships with PA staffs (Kideghesho *et al.*, 2007) were listed as the socio-economic factors responsible for conflicts (Allendorf *et al*., 2012).

Consequently, Holmes-Watts and Watts (2008) and Bennett (2016) reported socio-economic factors as being important to understanding people's perception on conservation given its role in ensuring conservation anthropogenically. Although, some studies support the secured access of human into National Parks a possible solution to conflicts as well as getting the locals more interested in conservation matters (Thondhlana *et al.,* 2016). As a result, social equity is promoted as a means of mitigating conflicts between local populations and staffs that are inclined towards conservation (Allendorf *et al*., 2012; Bennett and Dearden, 2014). It will also lessen people's reliance on forest resources in protected areas, which is a crucial step toward reducing dangerous wildlife interactions, particularly when humans travel into forest habitat or its borders (Nolte *et al*., 2013).

The number of people living in close enough proximity to protected areas has risen dramatically in recent years, as a result, manmade impact on conserved areas has increased. Traditional land disputes involving protected area administrators and hosting communities of the protected area have become more prevalent in Nigeria in recent years. The uniqueness of the land-base for most protected areas had been ascribed to public control prior to the 1978 land use regulations. The Property Use Act effectively shifted most communal land rights to the state, resulting in land disputes. However, expansion of subjoining rural settlements, conflicts in land ownership, forceful extraction of resources from the park and wrong attitude towards conservation amidst other drivers could pose serious threats to the LULC in Old Oyo National Park.

2.2 Land usage and Land cover changes

Plant distribution, water, arid areas, and frost on the earth's land surface, as well as the immediate subsurface, which includes biota, soil, landscape, groundwater and surface water (Lambin *et al.,* 2014), and mining site exposures and settlements are examples of structures built purely by activities of humans, are characterized by land cover (Le Roux *et al.,* 2014). Land use, on the contrary, is the planned application of a land management policy to the land cover by land managers or human agents in order to use the land cover (Zubair, 2006; Nanda *et al*., 2014), and it shows industrial zones, agricultural areas, logging, built-up areas, animal grazing, and mineral resource mining, to name a few, are all examples of human activities (Le Roux *et al.,* 2014; Nanda *et al*., 2014).

Conversion of grazed land to cropping systems, change in usage of fertilizer, improvement of drainage, irrigation installation and usage, plantation establishment, constructing farm/irrigation dams, pollution and land degradation, removal of vegetations, a new fire policy, dispersion of weeds and invasive species are all examples of change in use of land (Quentin *et al*., 2006; Nanda *et al*., 2014). These generally include any physical, biological and chemical changes attributable to management of land resources.

Land use and land cover change (LULCC), along with other forms of land loss/degradation, is one of the most significant environmental changes taking place today around the world (Le Roux *et al*., 2014). Conversion and modification are two broad categories for use of land and cover changes. When the usage of a land type or cover changes, conversion occurs, while modification occurs when the broad land use type or cover is maintained despite alterations in its characteristics (Bello *et al*., 2018). Sustainable resource use, according to Lambin (2005), is the usage of resources in the environment to generate products and services in a way that the resource's natural foundation is not depleted in the long run, while meeting the people’s potential requirement. Nearly all but one crucial aspect of environmental problems of this age is managing the changes on the surface of the earth caused by usage of land and cover changes (Daniels *et al*., 2008; Nanda *et al*., 2014).

Undisturbed (or wilderness) regions are projected to occupy 46 percent of the land surface of the earth. Eight thousand (8000) years ago, almost half of the earth's land area was covered by the forest, but today, only 30 percent of the surface of the land is occupied. In the process of satisfying the want for fibre and food, expansion of agriculture has occurred around the globe, encroached into the forests, steppes and savannas (Lambin *et al*., 2003; Bello *et al*., 2018).

As a result, classification of cover of the land has become a current study subject for a wide range of uses in recent years (Bello *et al*., 2018). A lot of research has been done all over the world to try to comprehend big changes in the usage and cover of land, including how they contribute to changing environmental conditions (Nanda *et al*., 2014). According to Baulies and Szejwach (1998), land usage patterns will be a part of a significant role to propel global environmental transition in the next few decades. Consequently, global mapping of protected areas, semi-natural areas, forest cover, and savanna biomes, as well as their dynamics, will help determine the biophysical effects of variations in the usage of land and cover within Earth's environment (Nanda *et al*., 2014). Agriculture is frequently identified as the primary cause of land cover change, particularly in tropical environments (Daniels *et al.*, 2008). FAO and ITPS (2015) recorded 35.9 Pg of soil are eroded from conventional agricultural landscapes, IPBES (2018) noted land degradation as a global problem whose extent has no quantitative consensus, thus affecting several land systems in all countries. Land usage and cover analysis and research are mainly needed to provide evidence-based support for enhancing land management policies and practices along with recognizing the complexities and modelling of natural landscape cycles and changes in local, provincial and international environmental change (Cotter *et al*., 2014; Kafi *et al*., 2014).

2.2.1 Effects of changes in usage and cover of land

Changes in use and cover of land led to unsustainable land use, which in turn leads to land degradation. Land degradation and destruction is the process by which one or more human-caused activities interacting on the land reduce the value of the biophysical natural environment (Fetene *et al*., 2019). IPBES (2018) also viewed land degradation as any change or disturbance to the land perceived to be deleterious or undesirable. As a hazard to environment, economics, and society, degradation of land stands alongside changing climate and loss of biodiversity, having a background in environments with significant biological variety and ecological productivity (Le Roux *et al.,* 2014; Nielsen *et al.,* 2014). Soil erosion, fertiliser depletion, water shortage, salinity, and biological cycle disruption are all examples of a fundamental and persistent problem. Land degradation has a negative impact on growth, biodiversity, and other environmental resources, additionally contributing to change in climate (Nielsen *et al*., 2014). It is a worldwide development concern; environmental deterioration and poverty are driving significance; nonetheless, it is usually overlooked and obscure politically. It will need a coordinated, long-term investment spanning industries, from all forms of government and private landowners, and also research to give reliable data, to prevent, if not rectify, the harm.

Ifeoluwa *et al*. (2011) employed multi periodic RS data and a GIS methodology to discover changes occurring in landscape usage and cover pattern in Akure, Nigeria, as well as their associated climate responses. Fabiyi (2006) investigated urban land use transition in Ibadan using remote sensing. The author evaluated land usage – vegetation changes using geospatial techniques. It was discovered that the Ibadan metropolis is undergoing significant dynamic changes, with vegetal cover, low species density, and rapid urbanization playing major roles.

In Ilorin and its environs, Kwara State, Zubair (2006) used RS data and GIS technique for change detection in use of land and its cover. Landsat satellite images of

Kwara State for three different years; 1972, 1986 and 2001 were analysed to identify the land use and land cover changes. For integrated land use / land cover analysis, Hof and Malami (2006) looked at pasture enclosures in North-Western part of Nigeria employing multi-sensor records from 1965 to 2002. They were successful in their mission to measure and map out the naturally vegetated lands in 1999 using Landsat ETM+ data from a land cover classification. This Landsat data was supplemented with field-based numerical data on productivity of plant in grassland and agricultural lands.

With the utilisation of remote sensing and GIS techniques, a LULC enumeration and surface modification was carried out by Omojola (1997) in a semi-parched region of Nigeria. Aerial photographs from 1962 and 1977, as well as Landsat MSS and SPOT XS pictures from 1986, were utilised by the author. The author was able to determine the usage and cover of the Land Features in the semi-parched zone of Nigeria using the optical (manual) approach of remote sensing analysis in the study. Abbas (2009) used Landsat data of 1975 and SPOT XS of 2005 to assess a synopsis of alterations in land cover in Nigeria. The author's study was limited, because he only considered two periods throughout a 35-year span.

Transformations in land usage and cover are the most apparent evidence of anthropogenic activities and the most major driver of biodiversity degradation, because biodiversity loss is exacerbated by climate change (Lambin *et al*., 2014).

Land use data is needed by local authorities to evaluate the environmental effects of energy resource production, manage wildlife resources, and reduce man-wildlife habitat conflicts (Venter *et al*., 2018). This will improve national assessments of land use trends and shifts, as well as the preparation of reports on impact on the environment and the assessment of future consequences on environmental policy.

2.3 Image Classification

Classification of image digitally is the method of assigning or organising pixels according to their data file values into a limited number of separate groups or object classes (Morgan *et al*., 2015). Normally, each pixel is viewed as a separate unit made up of values from so many spectral bands. Groups of identical picture element can be assembled into classes that fit the informative categories of interest for remote sensed data users by comparing them to each other and to pixels of known identity. Two types of digital image classification exist, and they are: supervised and unsupervised.

2.3.1 Supervised classification

This classification necessitates prior knowledge of the study area. Through a mixture of fieldwork, aerial photography analysis, cartography maps, and human experience with remotely sensed data, pixels are classified using a known character of certain locales, and the uses of the pixels are to obtain differing features of the land cover that represent homogeneous instances of use and cover of land classes to categorise the images. Training sites are the general name for these areas (Morgan *et al*., 2015).

2.3.2 Unsupervised classification

Erstwhile knowledge of the study location is not essential for this classification. This classification looks at a large quantity of unknown pixels, which are then separated into various classes based on normal image groupings. Techniques used to group pixels here is called statistical clustering where picture elements are assembled based on how close their brightness values are in each spectral band. To properly mark these clusters into land cover types, image analysts must understand the spectral characteristics of the study area (Morgan *et al*., 2015).

2.3.3 Vegetation mapping and Normalised difference vegetation index

Remotely sensed data are also very important for vegetation mapping. The internal structure of ‘‘green" leaves, which is clearly visible in spectral profiles of vegetations, causes peak reflectance in the near-infrared wavelengths. Chlorophyll pigments are present in the red wavelength which is where the greatest absorption occurs. The Normalised Difference Vegetation Index (NDVI) is among the most used vegetation parameters for land cover categorisation (Chen *et al*., 2021). It can also be used as an indicator of the environment to track changes in vegetation density across time and space, as well as the health and resilience of plant cover (Chen *et al*., 2021), which includes determining vegetation biophysical properties (Wu *et al*., 2020) and estimating net primary production (Huang *et al*., 2016). The NDVI is linked to several vegetation cover’s biophysical attributes, including the leaf area index (LAI), fractional vegetation cover, vegetation condition, and biomass. Several research has used the NDVI to for the estimation of greenness, vegetation biomass, primary production, and the fraction of absorbed photosynthetically active radiation (FAPAR) (Zhou *et al*., 2018) whose values increases as the density of green cover increases (Wu *et al*., 2020), and is computed from reflection values in the red and near infrared (Chen *et al*., 2021), with a wide variety of use in indices of vegetation (Zhang *et al*., 2016). The NDVI has the potential to be used as monitoring tool in the environment as ecological indicator for land cover health and viability, as well as variation in vegetation density throughout time and space (Zhang *et al*., 2016). NDVI values in vegetated habitats usually range from 0.1 in the arid areas to 0.8 in thick rain forest in the tropics (Chen *et al*., 2021). The pixel is labelled bare soil when the NDVI value is between 0.0 and 0.2; when the NDVI value is greater than 0.5, the image is classified as totally vegetated, according to Wu *et al*. (2020).

2.3.4 Change detection

Change monitoring systems are employed in a variety of ways, including land use and land cover trends, although, other many methods for change detection are available (Liu *et al*., 2018). Change detection is continuously monitoring and analysing change over time to identify major changes that have occurred over a sequence of images (Asokan and Anitha, 2019). Change maps are easier to generate with these significant changes.

Change detection in GIS is founded on the combination of numerous data sources. One of the advantages of utilising GIS to detect change is its capability to provide a broader assessment of the region being investigated as well as greater coverage (Gandhi *et al*., 2015). The change detection outcomes are affected by the presence of different source information and accuracies. Prakash and Kumar (2016) used remote sensing and Geographic Information System to assess the attributes of change in use of land as part of natural calamities. Rawat and Kumar (2015) explained detection in change in the cover of land using remote sensing and GIS, claiming that using these technologies made change detection simpler, more reliable, and less expensive. Using GIS as part of the change detection process has made it easier to incorporate source data. It has also effectively helped to visualise the improvements. Gandhi *et al*. (2015) in a flora cover shift recognition to evaluate the various vegetation types, GIS and remote sensing data were utilised to calculate the Normalised Difference Vegetation Index (NDVI).

2.4 History of biodiversity

Biological diversity denotes variation of biotic species from all ecosystems including land and aquatic ecosystems along with other ecological complexes that occur among them, such as habitat diversity, species diversity, and ecosystem diversity (Verburg *et al*., 2015).

Recently, the word "biodiversity" has been included in the idea of ecosystem services as a form of natural capital (Salzman *et al.*, 2018). Consequently, biodiversity depletion would endanger the ecosystems' ability for supply of products and the services they render (Burivalova *et al.*, 2017). Biodiversity depletion, according to Hooper *et al*. (2012), is most certainly one of the most crucial elements of ecological change in the twenty-first century, rivalling the problems of carbon dioxide increase. This was also supported by Baccini *et al*. (2017) who discussed tropical forest ecosystems as large CO_2 emitters when they are changed or degraded. Some studies have also suggested that if the ecosystem on which we depend lacks enough biodiversity to change and continue to meet our needs, our capability to adapt to a change in climate would be severely limited (Hosonuma *et al*., 2012; Verburg *et al*., 2015), which will hamper sustainability even for the future generation. Species extinction and slow changes in ecological groups are natural processes, but human actions have increased the pace of elimination by about 50-100 times that of the natural level, these loss results from fragmentation and degradation of habitats and it poses threat to our own survival and wellbeing (Lewis *et al*., 2017).

Human action has led to irreversible loss of diversity of life and this has been for years but in the last 50 years the losses has been more rapid and daunting in human history (Green facts, 2005; Paiva *et al*., 2015). Drivers of biodiversity loss includes but are not limited to climate change, over-exploitation, invasive species, land use change and pollution. These factors interact and amplify one another. Habitat loss is a direct cause of biodiversity loss while indirect drivers include poverty, economic activity, change in human population and technology.

Nigeria is richly blessed with vast expanse of natural vegetation ranging from tropical rainforest to woodland savannah as well as fauna (Imarhiagbe, 2020). Forest has continued to decrease rapidly because of human dependence on the forest for timber in the Nigeria (Adediran *et al*., 2016), for income generation (Levang *et al*., 2005), for food and medicinal purposes, and wildlife poaching (Hamann 2002). Extinction rate is on the rise with evident fauna and flora loss due to human pressures as a result of human civilization (Aguilera, 2019).

2.4.1 Anthropogenic drivers of Biodiversity loss

It has been established that biodiversity loss is synonymous to loss of ecosystem function and services if it continues (Oliver *et al*., 2015). The ecosystem functioning dynamics caused by biodiversity loss intensifies as the loss increases, reducing the insurance capacity provided by the diverse system (Oliver, 2015). The preservation of savanna is important to maintain biodiversity. With 60 percent of the world's population expected to be urban by 2025, urban expansion has an impact on land dynamics through the change of urban-rural links. Swiderska *et al*. (2008) reported the importance of assessing ecological space to understand land changes. With agriculture at the top of the chart for global land use change, population growth and increase need for food are the drivers of conversion of nature to land for agriculture followed by deforestation. Deforestation plays a role in global warming, hampers water regulation and disrupts the livelihoods of many of the poorest individuals on the earth (Fearnside, 2006; Imarhiagbe *et al*., 2020).

The greatest impact on biodiversity in the savanna is the change in land –use (Khan *et al*., 2008; Lambin and Meyfroidt, 2011). Species with a limited geographic range are almost always the most affected during habitat destruction, which destroy habitats and cause a decrease in species richness and variety in the forest, with different and often variable responses from diverse taxa (Aguilera, 2019). The abundance and composition of species are also influenced by fragmented boundary effects (Nielsen *et al*., 2014).

A number of species or group of species that are over exploited will experiential loss of species and eventually be driven to national or eventual global loss (Todd *et al*., 2017). Over-exploitation differs from the other instigators of loss of biodiversity because it precisely targets specific species (Brook *et al*., 2008). To prevent species loss in the future, it is important to understand and source information on risk of extinction of specific species (Murray, 2014; Ruland and Jeschke, 2017).

Naturally, introduced and invasive species have the potential to trigger extinctions, turn out to be a noxious pest, modify abiotic habitats, and spread diseases. (Nielsen *et al*., 2014). Hence, they generally disrupt the normal functions of ecosystems. Non-native species that spread themselves beyond their normal range are known as invasive species, on the other hand, Anthropogenic activities of man establish introduced species outside their natural range. Species with lower reproductive potentials are targeted or those that are native to predators or competitors (Adewumi *et al*., 2019). For example, in 1937, *Chromolaena odorata* was introduced into Nigeria via the shipment of infected seeds of *Gmelina arborea* Roxb from Sri Lanka to Enugu state. Since then, it has been widespread throughout the southern states. It became a major/noxious weed in plantations and agricultural fields, causing reduction in yield of domesticated crops (Ogundola and Liasu, 2007). On the account of relationships between invading species dominance and native species reduction in degraded environments, the indication of the negative effects of invading species was discovered (Didham *et al.*, 2005).

Hence, native species loss is sometimes driven by invasive species, which profiteers from habitat manipulation or ecological shifts (Didham *et al*., 2005). When species invade an area, they generally out strive the indigenous species by swiftly dispersing and obliterating the area's species diversity (Norgrove, 2007). Dueñas *et al*. (2018) reported that forests communities that are significantly altered by invasive or introduced species in the tropics are on islands that are heavily disturbed. Invasive species impacts the recovery of habitats by dominating these areas and generally obstructing the functioning of that ecosystem (Dueñas *et al*., 2018).

2.4.2 Effect of invasive species and climate change

The consequence of habitat loss on biodiversity can be seen in land use change activities, which are second only to climate change in importance. Climate change causes a shift in range to higher elevation and latitudes as species are distributed to areas that is suitable to them climatically and disappear from areas not favourable to them (Didham *et al*., 2005). The warming of climate affects the physical attributes of species important to possible mismatch among the species, consider the relationship involving pollinators and flora (Dueñas *et al*., 2018). It also shrinks the amount of habitat available indirectly and eliminates predators (Morris, 2010).

Tropical ectotherms and behavioural thermoregulation are the most probable especially disturbed by changing climate. Ectotherms are highly sensitive to changes in temperature and maintain a temperature that is extremely near to their optimum (Beaury *et al*., 2019a). The involvement of many other variables has made it problematic to attribute a causative relationship between change in climate and species abundance dynamics (Riginos, 2015; Beaury *et al*., 2019a). Change in climate and invasive species are the major persistent anthropogenic changes disturbing global ecosystems (USGCRP, 2018). When climate conditions begin to change, its impact is evident in changes in the distribution of energy, such as radiation, sunlight, and wind, which affects biota development and movement. (Beaury *et al*., 2019b). Therefore, some species of biota are favoured above others which can possibly bring in homogenisation or extinction of native species. Invasive species have the potential to increase competition in isolated regions because of change in climate. They homogenise anywhere native species may become subjected to biological connections which they have no experience of before in the history of their evolution (Shackleton *et al*., 2019). Habitat expansion and increased connectivity are typically seen to be beneficial to biological diversity (Beaury *et al.*, 2019b). As it has been reported, the expansion of invasive species beyond their range already poses a serious risk to native biodiversity, habitat expansion would allow some native species entry to new resources and take over new spaces (Beaury *et al*., 2019b).

Invasive plant species' distribution into and inside PAs may intensify because of changing climate (Foxcroft *et al.,* 2007). A major determinant of plant establishment is climate and change in the climate conditions may have significant effect on the invaded ecosystem. Change in rainfall and temperature may deteriorate the struggle of native species to resist the institution of species that are invasive (Diez *et al.,* 2012). The changes can also deter the establishment of invasive species by rendering some places less suitable, thereby, contracting its range for establishment (Taylor and Kumar, 2013). Information is required for adequate monitoring of the threat of invasive species under changing climate, on the recent and projected future spreading of species of plants that are invasive (Foxcroft *et al.,* 2007; Taylor and Kumar, 2013).

2.4.3 Feedbacks between the climate and the vegetation

Tropical forests are vitally influenced by global change in climate, along with their ability to mitigate climate change. The functionality of forests is being challenged by rising carbon monoxide levels in the atmosphere, rising temperatures, and changing rainfall patterns (Brienen *et al.,* 2015). If populations of species can adjust or acclimatise to new environmental circumstances, and/or if biological diversity can evolve so that species that are better adapted can become more prevalent, this can be about maintenance of proper functioning of the ecosystem. There is more evidence that old-growth savannas aren't in a stable state and are increasingly tilted towards biomass accumulation (Brienen *et al.,* 2015) and are shifting in composition of species with eventual erosion to native biota (Brienen *et al*., 2015). Various hypotheses, such as carbon dioxide enrichment or nitrogen accumulation, have been presented to explain these variations (Diez *et al*., 2012), but we still lack a general consensus. In comparison to the considerably longer timeline of mature tree regeneration (200-400 years), changes in diversity of species and transformation have been documented over very short durations (10-30 years) (Foxcroft *et al*., 2007) and when climate change takes place. Biological circumstances, particularly species and trait variety, are critical for boosting the long-term stability of ecosystem processes, according to several studies in grasslands and temperate forests (Wragg, 2017).

2.5 Soil seed bank and conservation of biodiversity

Healthy earth promotes plant growth, releases oxygen, retains water and reduces storm runoff, decomposes waste, links, and decomposes contaminants, and in the terrestrial food chain, it works as the initial course (Saatkamp *et al*., 2014). As it relates to forest biomass, Aweto (1981) opined that soil nutrient status is related to biomass which is evident in the relationship between cycling of nutrient. Long-term nitrogen storage and build-up in soil-derived living matter with forest structural properties (Kassa *et al*., 2019). It provides essential nutrients for plant growth as well as a suitable environment for micro-organisms and macro-organisms (Eni *et al.,* 2011). He *et al.* (2016) opined that a mutual relationship exists between vegetation and soil, with soil providing nutrient, anchorage, environment, and humidity for vegetation to establish successfully, while the vegetation makes available coverage and protection against direct sunlight and erosion for the soil and helps to keep the soil nutrient stable via litter fall and biodegradation of plant and animal litter. Soil characteristics (texture, volume, chemistry) is affected by vegetation, as a result, numerous vegetative properties (floristic structure, composition, and production) are affected. Land use change activities are also needed to monitor the seed bank of the soil categories in protected areas and its buffering area to enlighten policy makers and update management verdicts.

The success of seed bank is dependent upon the seed density that are viable when conditions for establishment is favourable (Taiwo *et al*., 2018). In the superficial soil, there is an aggregation of viable seeds which represent a living record of recent vegetation and a new potential seedlings emergence pattern of an area. This serves as an exact replica of the population that perished in hibernation which laid the material for recruitment, regeneration, and persistence of a population (Kassa *et al*., 2019). Oke *et al.* (2013) described soil seed bank as an aggregation of seeds in the soil that are viable and has the potential to replace adult plant and further explained that it is an important part of plant populations and may be used to forecast secondary regeneration (Oke *et al*., 2013). Based on their lifetime, Thompson *et al*. (1997) categorised seed banks as transient (less than a year), persistent for a short-term (Between 1 and 5 years), or persistent (more than 5 years). In transient, no seed survives for over a year, as opposed to persistent seeds, which survives for over a year as it allows the species to be able to withstand periods of disruption and devastation (Thompson *et al*., 1997). Soil seed banks are a type of spatial and temporal dispersion that allows for the invasion of new areas (Oke *et al*., 2013). This is specifically important for rare species' survival. The ecological functions performed by soil seed bank makes their management an effective component in a restoration programme (Kassa *et al*., 2019).

2.5.1 Characteristics of seed bank

When environmental conditions are favourable, replacement of plant is necessary and dependent on the readiness of the seeds in the seed bank to germinate (Savadago *et al*., 2017). The major survival mechanism of certain plant is the longevity of the seeds and it promotes continuous germplasm. This longevity is dependent on seed quality, burial depth and environmental circumstances (Oke, 2013). Baskin and Baskin (2014) opined that seed dormancy affects the seed bank reservoir as seed germination is hampered by both internal and extrinsic causes. The internal factors include seed coat, immature embryo and in the seed, there is the existence of biochemical inhibitor while external factors include temperature and soil water content. Dormancy preserved seeds and guaranteed the existence of the species in the face of extinction (Akinyemi and Oke, 2013). Direct seed extraction and indirect seed identification procedures based on germination assays have both been established as procedures for seed bank evaluation (Abella *et al*., 2013). Both methods provided the same result (Abella *et al*., 2013) while Baskin and Baskin (2014) revealed the methods did not. Direct seed extraction was reliable in estimation of more plant seeds (Abella *et al*., 2013), this could include seeds that are not viable (Tessema *et al*., 2016). However, it omits small-sized seeds, which leads to exaggeration of densities of seed (Kassahun *et al*., 2009).

Seed germination procedures, on the other hand, have a great capability for distinguishing non-viable seeds from viable seeds (Gioria *et al*., 2019), it can produce good outcomes if the growth period is adequately extensive and field environments are accurately replicated to allow all seeds, even latent seeds, to germinate (Abella *et al*., 2013). Assessment of inactive regeneration depending solely on above-ground flora have a tendency to overlook the important role that the seed bank in the soil plays in ecosystem variability and resiliency (Dreber *et al*., 2011). Understanding the complexity of the seed bank domiciled in the soil profile is critical for knowledge of the history of management of land use as well as future restoration management techniques. (Jonason *et al*., 2014).

2.5.2 Seed bank in savanna ecosystem

Seed banks, like the above-ground plant community, are variable compositionally and in terms of abundance, and are susceptible to factors that affect seed supplies and declines (Olatunji *et al*., 2015). In the dry season, savanna habitats are marked by scarcity of surface water and rivers. The vegetation composition of hardly disturbed ecosystems, such as grasslands, is usually recognized to be mostly governed by vegetative development and only a little influenced by seed bank composition (Oladipo and Oke, 2007; Jarvis *et al*., 2015). Reduced seed availability in seed bank of soil is a main blockade to savanna ecosystem recovery. The density, persistence and viability of seed in the soil profile are important for the ecosystem restoration (Qian *et al*., 2016), especially for ecosystems that are subject to frequent disturbances (Savadogo *et al*., 2017). A seed bank in soil profile benefits both individual species and communities of plant that adequately represents all of the flora of an ecosystem through conservation (Fisher *et al*., 2009).

Sawadogo (2009) reported that most savanna woodlands in Burkina Faso are legally or illegally grazed. Uncontrolled access of grazing livestock can change the floral communities and exotic or non-native weeds may invade, resulting in a weed invasion of the ecosystem. These disturbances can result in protracted periods of bare areas and a change in composition of species from pleasant perennials to unpleasant yearly species over time. An examination of the spatial distribution of buried intact seeds is of great significance in plant conservation because it can serve as an indicator of the ability for seed turnover and restoration (Kassahun *et al*., 2009).

Species that are undesirable can be regenerated through seed banks (Saatkamp *et al*., 2014) although, seeds covered by the subsurface layer of the soil can have crucial impacts on conservation management if certain species have been extirpated from the environment but are still available in the seed bank of the soil (Gioria and Pysek, 2015). De Andrade and Miranda (2014) reported that if seed banks are to become valuable indicators of ecosystem status and health, a consistent sampling of sites is essential to monitor emerged flora.

2.5.3 Soil seed bank species composition and correspondence with standing vegetation

Grasslands, wetlands and woodlands (Gomes *et al*., 2019) have been observed to lack of connection among the plant species enumerated in the seed bank and the species encountered in the standing flora. In Northern England, Thompson and Grime (2012) observed that in a variety of vegetation types, there was a lack of connection among the composition of species of the seed bank in the soil in relation to the standing vegetation. Because the current vegetation is expected to be an important source of local seed or composition of the seed bank, the absence of comparison between some seed banks and the related vegetation appears self-contradictory (Awodoyin *et al*., 2013). The seed bank of the soil and the vegetation above ground are closely linked and have solid optimistic response particularly during early succession stages and senescence of their seed bank (Olatunji *et al*., 2015) which may dwindle over time as the number of yearly species on the vegetation declines (Siebert and Drebber, 2019).

Mohammed and Hussein (2008) reported that natural or anthropogenic disturbances of standing vegetation might also affect seed quantity and structure of various kinds of species' seeds in the soil. Siebert and Drebber (2019) discovered that the during climax processes, viable seed were present in the soil from most of the prior successional stages, concluding that these seeds were generated from vegetation from those climax stages. According to other research, the majority of the seed present in the soil comes from the local area rather than from immigration (Akinyemi and Oke, 2013). Some immigration does occur, Thompson and Grime (2012) discovered that dispersal of small amounts of seed from a regrowth vegetation stand into undisturbed forest and their integration into the seed bank is possible.

Density of seed bank, and species abundance diminishes with succession maturity, according to studies of succession communities (Oladipo and Oke, 2007; Augusto *et al.,* 2009). About 108 studies that were carried out between 1945 and 2006 were reviewed by Hopfensperger (2007) and those results revealed that in savanna ecosystems, the least of resemblance that exists between existing vegetation and its related seed bank is 31%. In order to assess inflows of invasive species, it is necessary to monitor the interaction between standing vegetation and seed banks (Vieira *et al*., 2015) and input between components of the vegetation below and above.

2.5.3.1 Seed lifespan and depth dispersion in the soil

The study carried out by Schwab and Kiehl (2017) revealed that there is a relationship between the depth and the seed density within the soil profile with some species prevalent on the soil surface, while others are found in deeper strata, and some have a consistent distribution with depth (Thompson and Grime, 2012). This was supported by Traba *et al.* (2004) that the viability of seed is preserved longer if the depth of burying in the soil is increased. Assumptions were made by Oke *et al*. (2013) that seeds that are buried deeply are older than seed near the soil surface. The results of Senbeta and Teketay (2002) in their study in woodland soils indicated that seed loss is larger in the top soil layers, with preservation occurring only at deeper depth especially in undisturbed woodland.

Gomes *et al*. (2019) found that mineral soils had more quantity of seed that are viable than peat soils, although it was also suggested that this could be due to the impervious nature of peat which prevents seeds from entering deeper layers where there are less favourable conditions for their survival. Thompson and Grime (2012) studied pasture seed banks and observed the number of viable seeds in water logged soils. In late succession systems, undisturbed forests, for example, have a low number of underground seeds that are viable (Oke *et al.,* 2013), although additional seed inputs may occur as a result of canopy gaps opening.

2.5.3.2 Importance of seed banks to conservation

Seed banks are a prime determinant of undesired species regeneration; for example, on agricultural soil, the majority of species in seed banks are seasonal weeds. (Oke *et al*., 2013). Buried seeds, on the other hand, can have significant conservation implications when essential or favoured species have already been eroded from the vegetation but have survived in the soil seed bank (Jiang *et al*., 2013). Lowering the water level in freshwater wetlands allows species recruitment from the seed bank in the soil (Gioria *et al*., 2015).

Long-lived seed species are predominant due to the survival of years of high-water availability as seeds and re-establish themselves in the vegetation during the following depletion, or because their survival during the pullback as seeds affords them the opportunity to re-establish themselves in the vegetation when standing water returns (Oke *et al*., 2013). Seed banks have become less effective for restoring plant communities with short-lived seeds (Newmaster *et al.,* 2006). Seed in the soil profile stays in the soil for as long as necessary and only regenerate when conditions necessary for their germination is available and therefore can serve as a bank for species thought lost to resurface. This is an important implication for biodiversity conservation.

2.6 Carbon sequestration in Nigeria

CO_2 sequestration is the process of extracting CO_2 from the atmosphere and storing it in different C reservoirs in different lifetimes which could be between photosynthesis (Gain) and respiration (Losses) in the ecosystem is known as carbon sequestration (Jha, 2015). Forests function as a sink for carbon through growing above-ground biodiversity and the content of organic carbon in the soil (Banskota *et al*., 2007; Worku *et al*., 2012). Protected areas, which are created with the primary objectives of conservation of biodiversity in mind, typically represent legal constraints on land use reforms and could play a significant part in the preservation of carbon reserves terrestrial ecosystems (Fragoso-López *et al*., 2017). Globally, habitats within protected areas have been assessed to stockpile more than 15 percent of carbon or 312 gigatons of stocked carbon in terrestrial ecosystem (Fragoso-López *et al*., 2017). Recent research, however, shows that despite the fact that protected areas typically minimize logging compared to areas that are unprotected, they are not completely free of changes in land usage inside them (Solomon *et al*., 2018).

Savannah biomes retain much lower amounts of carbon per hectare (60-70 t C/ha), but are important because of their large extent. Nearly all carbon stock estimations from tropical forests are based on several biome-average sets of data, although specific forest types or biomes are assigned a single, typical forest carbon value for every unit area (De Oliveira *et al*., 2019). Grace *et al*. (2006) inferred that most savanna would accumulate significant amount of carbon and they would have larger sinks if they were protected against fire and grazing. Carbon sequestration levels can be 0.14 tons of carbon per hectare or 0.39 tons of carbon per hectare per year in these habitats. Consensus on how much carbon is released by changes in tropical savanna land use is also yet to be achieved (Van der Werf *et al*., 2009). Thus, there is a pressing need to calibrate and create techniques for assessing the biomass of tropical forests and their spatial distribution (De Oliveira *et al*., 2019).

Consequently, the distribution of biomass/carbon stocks tends to vary from one location to another and from one species to another. Therefore, it is imperative to describe the peculiar plant population structure and composition of the study area so that we can see how variation in structure and composition is expressed in variation in density of biomass and carbon stock.

2.6.1 Allometric equation/ Biomass estimation equation

Measurements of Diameter at breast height (DBH) and height are used as standards for allometric calculations. The biomass or volume of aboveground woody constituents is determined using these allometric formulas (Kebede and Soromessa, 2018). This process of estimating the biomass of woody species existing in a tree plantation or forest using biomass calculations is a standard and low-cost technique (Specht and West, 2003), these calculations are formed based on the woody species' weight in proportion to its height and DBH as measured by tree samples. Assessing the biomass of trees is essential for estimating the forest productivity, it allows for the measurement of carbon sequestration in roots, leaves, and wood (Specht and West, 2003), as well as sustainability of the forest. Estimating the amount of atmospheric CO_2

that the forest ecosystem can sequester allows for estimation of the quantity of atmospheric carbon that the forest can sequester.

Accurate estimation of forest biomass is critical for a various purpose, including extraction of timber, monitoring the changes in the carbon stock in the forest, and the understanding the global cycle of carbon (Kebede and Soromessa, 2018). The role of climate change mitigation and carbon sequestration is saddled by the forest; Forests play a crucial role in the mitigation of climate change by sequestration of carbon. CO2 is absorbed from the environment and stored in their leaves, stems, roots, and branches through photosynthesis. Carbon accounts for around half of all dry forest biomass (UNFCCC, 2010). For estimation of biomass in aboveground (AGB) in woody species and plots, construction and employment of allometric equations is the conventional way (Brown *et al*., 1989).

Allometric calculations are essential for calculating carbon storage and biomass in terrestrial ecosystems. Using tropical species mixtures, numerous models have been constructed for prediction of biomass (e. g. Brown *et al*., 1989). Forests in the tropics, particularly, are very important in storing 26 percent of global carbon in biomass and soils, as well as terrestrial carbon cycle (Grace *et al*., 2006). However, realistic estimations of sequestered carbon in tropical forests are inadequate in many different areas, due to a lack of suitable allometric equation for estimating biomass in ecosystems in the tropics which are rich in biodiversity.

2.6.2 Carbon stock estimation in savanna ecosystem

The savanna biome is categorized by a codominance of woody species, shrubs and grasses, this ranges from sparsely forested grasslands to densely forested areas habitats where trees dominate (Ciais *et al*., 2011). Tropical grasslands and savannahs are large types of habitats that include a range from grasslands with no trees to the open forest. Savannahs and grasslands in tropical areas are largely found in Africa, Australia and South America (Grace *et al*., 2006). Savanna biomes are characterised by fire outbreaks. Above ground biomass carbon is estimated at 9.4 Mg/ha, below-ground biomass carbon at 19 Mg/ha and 174 Mg/ha for carbon in the soil. Typically, above-ground biomass is a component of tree density within the ecosystem. Total soil organic carbon reserves in African savannahs were estimated to be around 110 Mg/ha in a recent study, despite substantial geographical variation and minimal association between soil carbon stocks and vegetation (De Oliveira *et al*., 2019). When it comes to soil carbon reserves, African savannahs can have carbon total densities that rival forests (Grace *et al*., 2006).

Savanna habitats are greatly impacted by conversion of habitat, which has been valued to be around 1% per annum and may have been a great part of ecosystems that are transformed (Grace *et al*., 2006). Ciais *et al*. (2011) identified significant gaps in knowledge about tropical savannas and grassland ecosystems. These ecosystems aren't adequately represented in models of terrestrial ecosystems, making it difficult to assess their function in the global carbon cycle (Epple, 2012).

De Oliveira *et al*. (2019) combined the biomass both above and below ground, as well as estimation of soil organic carbon to a depth of 1 metre. According to this study, a total of 7.5 Gt of carbon is stored in the biomass and soils of the Nigerian terrestrial ecosystems.

2.6.3 Carbon stock estimation in carbon pools

Estimating the biomass density of ecosystem components is the first step in ecosystem carbon accounting. Because of their large expanse, trees in diverse ecosystems have great potential for emission / sequestration (Agevi *et al*., 2017). According to Brown *et al*. (1989), in highly diverse areas, just over 95% of said variability in tropical forest carbon stocks in above ground can be explained solely DBH. Thus, using DBH-based allometric equations is the easiest and the most extensively utilised method for obtaining above-ground biomass from woodlands and forests in general. Using DBH as a single biomass stock predictor variable is adequate for this study. To determine the carbon equivalent of the computed biomass, 50% of it is presumed to be carbon, thus multiplying the biomass estimate by 0.5 to obtain the equivalent carbon estimate (Brown *et al*., 1989). Nonetheless, the analysis followed IPCC (2006), the 0.47 is the proxy carbon fraction. Because it is assumed that biomass carbon content changes only slightly between different types of trees, this factor of conversion is utilised across all species of trees (Brown *et al*., 1989).

In most African countries including Nigeria, there is slow progression into the quantification of soil carbon. Sequestration of carbon in soil is both gainful and sustainable environmentally (Jha, 2015). Agevi *et al*. (2017) reported that the distribution of vegetation will significantly affect the storage of carbon in soils. Factors affecting the estimates of Soil Organic Carbon accounting include the depth to which carbon is measured, generally 30 cm (IPCC, 2006), and the time lag before equilibrium stock is achieved after a shift in land use, approximately 20 years. Accurate inventorying and monitoring of the different carbon pools under different types of land use is crucial in understanding their function as either sinks or carbon sources (Agevi *et al*., 2017). Awareness of how different management activities, disturbances, age and composition of terrestrial ecosystems in Nigeria impact carbon storage at landscape level is critical for a reliable estimate of its potential for C sequestration. Therefore, quantifying biomass / carbon stocks in above ground carbon pool is imperative; this will go a long way towards providing more reliable data on carbon stocks towards above ground carbon pool.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the study site

The ruins of Oyo-Ile, the Yoruba Empire's historic political capital, inspired the name Old Oyo National Park (OONP), and is among Nigeria's eight National Parks. It was established in the 1991 by Decree no. 36 from Upper Ogun Forest reserve and gazetted in 1936 while Oyo-Ile Forest reserve was gazetted in 1941. In late 1960s and early months of 1970s, it existed as a game reserve due to its exceptional to host plant and animal species population and diversity. It was founded with the goal of protecting, preserving, conserving, and managing representative samples of local flora and fauna of the tropical derived savanna zone of Nigeria. This encouraged and promoted sustainable richness and growth of biological diversity for botanical and zoological specimens for scientific research. Towns adjoining OONP include Sepeteri, Tede, Igboho, Saki, Igbeti. Eleven L.G.A. surrounds the Park with 10 in Oyo and 1 in Kwara states, respectively. Visitations by the public to the National Park is encouraged in order for them to examine, adore and appreciate the beauty, spiritual and nature’s ecological values in a healthy/wholesome environment. The study area is the Marguba Range of Old Oyo National Park (Figure 3.1)

3.1.1 Vegetation structure and Topography of Old Oyo National Park

The Park is in Northern Oyo State and Southern Kwara states along Latitude $8^o15'$ and $9^o00'$ N, Longitude $3^o35'$ and $4^o42'$ E. The Park covers a total land area of 2,512 km^2 (the fourth largest Park in Nigeria). It is composed mainly of lowland plains undulating from 330-508 m above the sea level. It is drained by two main River systems: River Ogun flowing southwards to the Atlantic Ocean and River Tessi flowing northwards to the River Niger. The Ogun River runs down the valleys that drain the woodlands. Other river tributaries in the park include Owe and Owu which drain in the south and northern regions, respectively. The Northern zone of the park has rocky outcrops of granite at Oyo-Ile with caves and rock shelters in the extreme north. The central parts of the park include hills, rocky outcrops and ridges which are good for mountaineering.

The Park has four types of vegetation which include:

i. Dense woodlands and forest outliers in the Southeast part,
ii. Mixed open Savannah woodland in the central part,
iii. Vegetation outcrop in the northeast and
iv. Riparian grassland and fringing woodland occupying the forest plains and valleys along the Ogun River.

3.2 Research Studies

The research was sub-divided into four (4) studies as highlighted below:

STUDY 1: A Preliminary survey was conducted with the aid of structured questionnaires to investigate the perception of the local people on the impact of land use/land cover changes on human-wildlife conflict in the buffer zone of Marguba Range of Old Oyo National Park using mixed method (Quantitative and Qualitative).

STUDY 2: Landsat Imageries were obtained and analysed with ArcGIS Version 10 to generate maps that were used to assess the past and current usage and land cover in the buffer zone and core area of OONP.

STUDY 3: Floristic survey was carried out to compare the phytosociological attributes of the floras in the buffer and core zones of the OONP (Figure 3.1), and to derive values for the indices of flora diversity in the Park.

STUDY 4: Collection of soil samples from plots located along transects so as to compare the above ground flora with the flora composition of the soil seed bank. The influence of the soil seed bank on biodiversity conservation in the Park was determined.

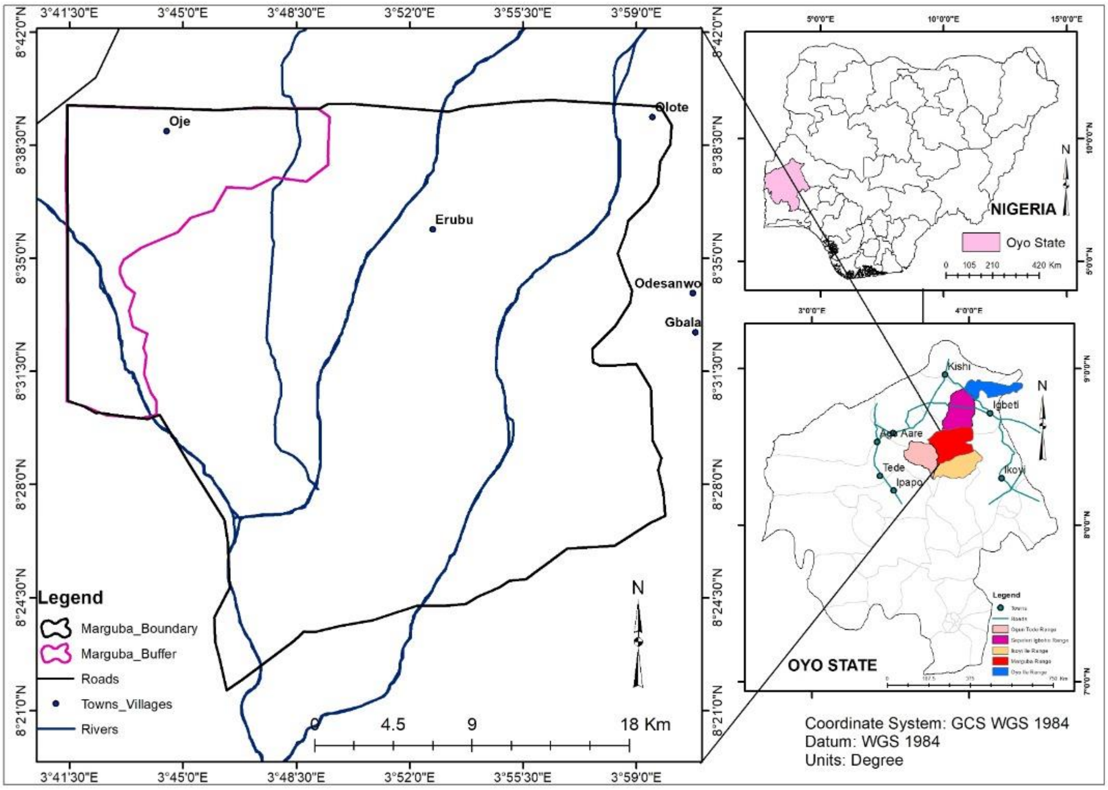

Figure 3.1. **Digitised Map of the Marguba Range showing the Buffer and Core zones of Marguba Range of Old Oyo National Park.**

3.3 Climate data

Climatic variables for 1990 – 2019 were obtained from WorldClim (http://worldclim.org). This database provides high resolution (1 km) bioclimatic variables. The bioclimatic layers capture the climate averages, extremes and variabilities. They are recognised as significant drivers of species distributions at the regional and global levels (Elith and Leathwick, 2009). The bioclimatic variables important to this study were temperature, precipitation, and relative humidity. These data were downloaded as daily output and were eventually pooled on a yearly basis for clear significance in the data trend.

3.4 Preliminary Survey

Structured questionnaires (117) were administered to farmers in villages surrounding the Marguba range to determine if agricultural activities were going on in and around the Marguba range of the OONP; the ecological changes observed by the farmers; and the government policy existing in the park. The structured questionnaire included: Demographic attributes of the population in the study area, farming practices, Soil and water relations with agricultural productivity, statement of farmers' knowledge of environmental problems/Park accessibility, vegetation availability and dynamics of Trees, shrubs, and animals. The questionnaires were administered through in-depth interviews and one–on–one interview. Snowballing technique was used where information was obtained from a farmer who in-turn recommended another farmer in the sampling frame after interview and so on till the relevant recommendations were exhausted and repetition starts.

3.4.1 Sample size and Sampling procedure

Sample size was drawn from the data provided by Park Rangers and Research Officers of Old Oyo National Park, Oyo state, Nigeria. Hence, 50% of the population of farmers whose farms were close to the Park were interviewed using a well-structured interview guide in each village. The seven (7) villages (Table 3.1) near the Marguba range of Old Oyo National Park were purposively sampled and a total of 84 questionnaires were retrieved. The multi-staged sampling design was used where villages were selected purposively, farms in close proximity (1 km to the buffer zone) to the Park were selected, the farmers were selected through snowballing technique and interviewed one-on-one. In-Depth Interviews (IDI) with semi structured questions were used to acquire qualitative data with a few closed ended questions from Rangers and farmers around the Park on the basis of their expertise and long-term experience with farming around the Park. Following Newing (2010), Quantitative data and direct quotes from respondents were utilized as evidence to back up their statements and express more nuanced meanings. According to Newing (2010), respondents' direct quotes and quantitative data were used as facts to back up their statements and articulate more in-depth meanings.

3.4.2 Validity of research instrument:

The research instrument was validated by socio-demographic agricultural extension professionals at the Department of Agricultural Extension and Rural Development, University of Ibadan. The validation was conducted to check whether the right questions were asked, if they were asked in the right format and the suitability of the research instrument for the selected objective. The research instrument was validated by Dr. N. T. Tegbe.

3.4.3 Perceptions

The respondents were given a list of twenty-three (23) possible perceptions to knowledge of environmental problems and accessibility to the National Park and were asked to indicate their level of perception on a 3-point scale of Strongly agree, Undecided and Disagree. While nominal values of 1, 2 and 3 were assigned, respectively. A general perception score was obtained to indicate favourable or unfavourable perception. Respondents with scores equal to and above the mean were regarded as being favourable while respondents with scores below the mean were regarded as being unfavourable according to the procedure of Bouter *et al*. (2016).

3.4.3.1 Knowledge of the Use of Charcoal and Firewood

The respondents generated a list of trees to indicate knowledge of their use as fuel, respondents were required to indicate whether the trees were used for firewood, charcoal, or medicine with nominal values of 1, 2 and 3, respectively. While response option of Harvested and not harvested had a score of 1 and 2, respectively. The responses were summed, and the mean was calculated to categorize the respondents into high and low knowledge.

Table 3.1. Distribution of respondents in communities surrounding Marguba Range of Old Oyo National Park

Village	No. of farmers	Selected participants (50 %)	Retrieved questionnaires
Abanla	36	18	15
Oke-Odoogun	18	9	5
Kanga	42	21	15
Budo egede	24	12	8
Alapata	20	10	7
Imodi	52	26	22
Ajirowo	34	17	12

Field survey, 2017

3.4.4 Data analysis

Statistical analysis of social science data was done with IBM SPSS (Statistical Package of the Social Sciences) software version 21 (SPSS Inc., USA). The descriptive statistics used to summarise the data included mean, frequency, minimum and maximum values, and standard error. The qualitative analysis was carried out by identifying codes. Themes and subthemes were generated, and all data were transported into NVIVO version 12 which was used for data management. Some verbatim quotes were used to establish and support the findings.

3.5 Acquisition of Imageries

3.5.1 Data source for land cover change

Primary data were sourced from the United States Geological Survey Earth explorer (USGS-EE) which comprised of Enhanced Thematic Mapper (ETM), Operational Land Imager (OLI)/Thermal Infrared Sensor (TIRS) and Thematic Mapper (TM). Imageries from Landsat of the study area and its surroundings for 1990, 2000, 2010 and 2019 were obtained (Table 3.2). The topographic map covering the Marguba Range of Old Oyo National Park and its surroundings was obtained.

3.5.2 Digital image processing of Landsat imageries of 1990-2019

Geo-spatial analysis was carried out with the use of ArcGIS 10.3 software which generated maps that showed the land use classification of the study area. Multi-temporal Landsat imageries of path/row 191/054 were acquired over the past 30 years (1990-2019) (Table 3.2). All images were of good quality with less than 10% cloud cover except for 2010 image with striping errors which were corrected using de-striping tool in ENVI 5.0 software. For ortho-rectification of the satellite images, intensive image pre-processing technique such as radiometric correction, image sub setting (clipping) and band combinations were done. The images were stacked and further processed in ArcMAP 10.7 software. This process was followed by masking the study location out from the stacked satellite imageries.

Field survey to mark coordinates was carried out using the Global Positioning System (GPS). This was done to achieve precise location points for the land use and cover types used in the classification scheme, and also to create ArcGIS training sites. The 1990, 2000 and 2010 imageries could not be checked against ground truth because they existed a long time before now but were the historical data that were used to validate the interpretation made for the area. However, the 2019 satellite image was

Table 3.2. Landsat Data of Marguba Range of Old Oyo National Park sourced from United States Geological Survey-Earth Explorer in 2019

DATA	DATE ACQUIRED	SPATIAL RESOLUTION (Multispectral bands)	PATH/ROW	Cloud cover (%)
Landsat Thematic Mapper (Landsat 4 TM)	1990 - Dec. 27	30 m	191/054	<10
Landsat Enhanced Thematic Mapper (Landsat 7 ETM)	2000 - Feb. 06	30 m	191/054	<10
Landsat Enhanced Thematic Mapper (Landsat 7 ETM)	2010 - Feb. 01	30 m	191/054	<10
Landsat 8 OLI/TIRS	2019 - Jan. 30	30 m	191/054	<10

checked against ground truth directly. Images were pre-processed according to the method of Kaufman (1989).

Supervised classification was used for image classification (Figure 3.2) in the ENVI environment. A training site was created by identifying the different land use types on the images. Several training sites were created in order to take care of the different classes on the images. The training is known as signature file in ENVI 5.0 software where the analysis was carried out. A supervised classification was carried out on individual images using a false colour composite in order to select the Region of Interest (ROI) for features like wetland, shrubs/grass, and forest using the maximum likelihood classification technique according to Adedeji *et al*. (2015).

True colour composite was applied to select ROI of built-up area, Bare surface/Rocky outcrops. The ROI helped to produce the map by designating a region in the map solely on the basis of colour allocated to that classification and the spectral uniformity of the pixels in the selected region.

3.5.2.1 Selection of Feature of Land Use Classes and Image classification

Five categories Land use/ Land-Cover were identified in reference to restrictions caused by the low spatial resolution/clarity of data from LANDSAT Imagery. These classifications corresponded to the first level of the United States Geological Survey (USGS) scheme (Table 3.3). The procedure for geospatial analysis is shown below;

a) For each year, a composite image was made by joining the bands in the raster computing toolbox through the use of composite band tool.
b) Employing the use of the clip feature tool in the raster processing toolbox, Marguba Range of Old Oyo National Park was cropped out of the composite imagery.
c) The imageries clipped were classified into five land use types (Forest, Built-up, Shrubland/Grassland, Bare surface/Rock Outcrops and Wetlands)
d) Four maps showing the land use types were then produced for 1990, 2000, 2010 and 2019, respectively
e) Area of each land use type per year was calculated using Eqn. 3.1

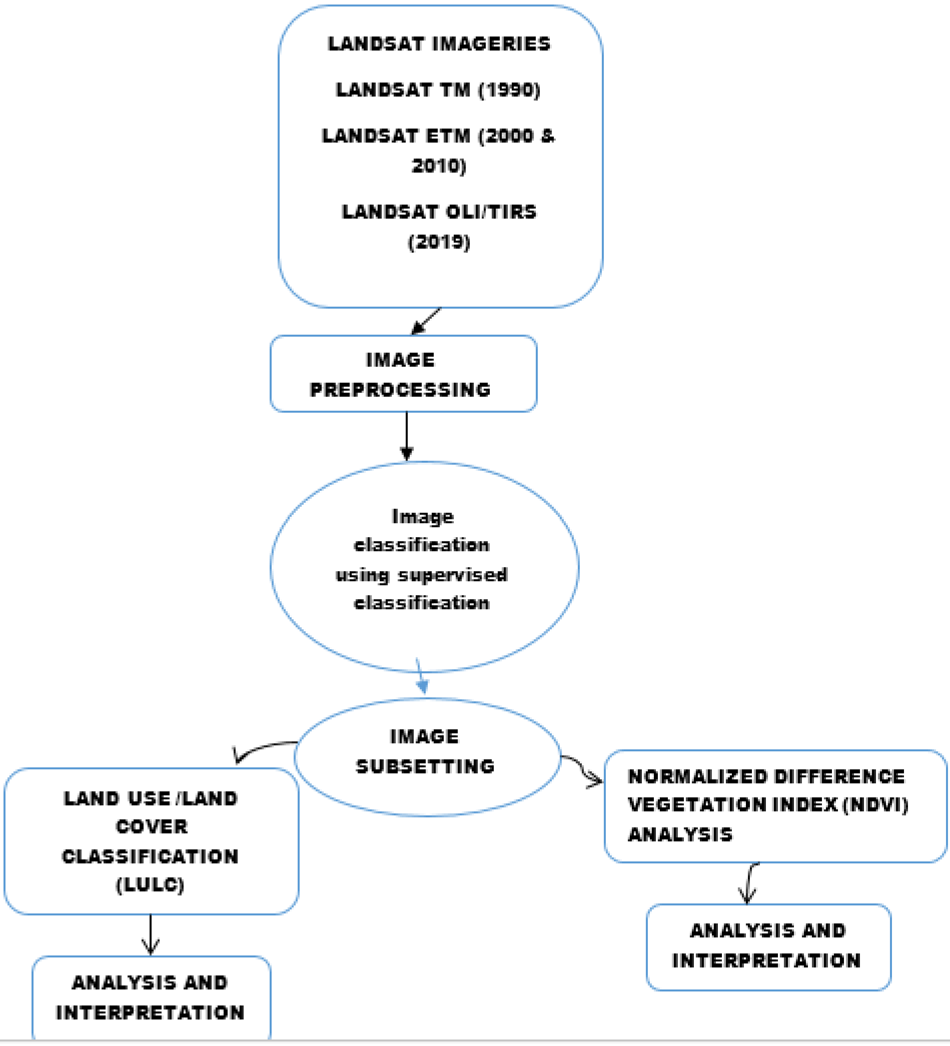

Figure 3.2. Thematic workflow for Land use/ Land cover classification and Normalised Difference Vegetation Index (NDVI)

$Area\ (m^2) =$

$Cell\ size\ (pixels)\ X\ Count\ (Number\ of\ pixel\ in\ each\ land\ use\ type) \ldots Eqn. 3.1$ it was converted to Hectares using Eqn. 3.2

$$Hectares = \frac{Area\ (m^2)}{10{,}000} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots Eqn. 3.2$$

3.5.2.2 Image classification of the land classes and assessment of the accuracy level

This is done to estimate how well the classified classes represents the real world. To determine the classification accuracy of the images, standard criteria were used as follows:

1. Kappa coefficient: this ranges from 0 to 1 and it estimates how much better the classification is compared to randomly assigned class values to each pixel in each classified land use class. This takes care of the effect of chance in classification, values obtained connotes that the percentage of accuracy is greater than chance (Miller and Yool, 2002).

2. User accuracy: the proportion of appropriately classified pixels to the total pixels categorized in a given land use class following Eqn. 3.3. This is also known as the Positive predictive power

   $User's\ accuracy = \frac{a}{a+b} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots Eqn. 3.3$

3. Producers' accuracy: This followed the method used by Rogan *et al.* (2002) where the total quantity of pixels with correct classification was used to divide the total number of sampled points in each class following Eqn. 3.4. Also known as sensitivity

   $Producer's\ accuracy = \frac{a}{a+c} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots Eqn. 3.4$

Where:

a = The number of times a classification matched the value that was observed

b = When a point was not observed as X, the number of times it was categorised as X was calculated

c = When a point was detected as X, the number of times it was not categorized as X was counted

Table 3.3. Land use types/land cover classifications identified in the Marguba Range of Old Oyo National Park

LULC types	Description
Forest vegetation	This is an area of land covered with mature trees and other plants
Shrubland/Grassland	This is an area of land covered mainly with shrubs and grass plants
Bare surface/Rocky outcrop	Area of land covered with bare soils, scanty grass and exposed rocks
Wetlands	This is an area of land inundated with water
Built-up	Areas that have been populated with residential, commercial, industrial, roads and facilities.

3.5.2.3 Magnitude of change

This followed the procedure of Adedeji *et al*. (2015) where a negative value signifies a decrease in the LULC size while a positive value indicates an increase in the LULC class size. This was calculated using Eqn. 3.5

$$\text{Magnitude of Change} = Magnitude\ of\ the\ current\ year - Magnitude\ of\ the\ previous\ year \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. Eqn\ 3.5$$

3.5.3 Creating Normalised Difference Vegetation Index (NDVI) maps for Marguba Range of Old Oyo National Park

In general, NDVI uses two properties to quantify healthy vegetation, that is near-infrared (NIR) (because vegetation strongly reflects it) and it also uses red light (because it is strongly absorbed by plants) (Zhou *et al*., 2018). The human eyes see vegetation as the colour green for this same reason. Imageries with Red and Near Infrared (NIR) bands were acquired while High and low vegetations were classified. The Normalised Difference Vegetation Index (NDVI) also was achieved through the raster calculation analysis which was done using the raster calculator in ArcMap 10.7 Spatial Analyst toolbox. Hence, composite band tools were used to generate the NDVI maps. The general interpretation of results was used, where: Pixels with high NDVI values indicated high vegetation, low values indicated less vegetation and a negative value is a good indicator of water / non vegetated surfaces (Wu *et al*., 2020). Normalised Differential Vegetation Index (NDVI) was used to understand vegetation greenness (Zhou *et al*., 2018).

The index was calculated using Eqn 3.6:

$$\text{NDVI} = \frac{\text{pNIR}-\text{pRED}}{\text{pNIR}+\text{pRED}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eqn. 3.6}$$

Where NDVI = Normalised Differential Vegetation Index

RED = Red region

NIR = Near-Infrared region

The NDVI varies between -1.0 and +1.0.

3.6 Floristic survey

3.6.1 Period of field survey

Floristic survey and soil sample collection were carried out over two consecutive years during the two rainy season and two dry season spanning from 2017-2018 and 2018-2019. The seed bank analysis was conducted after field trip during each season at the Department of Crop Protection and Environmental Biology Screen House.

3.6.2 Floristic composition of the standing vegetation of the Buffer and Core zones of the Marguba Range of Old Oyo National Park

Phytosociological assessments were carried out to determine the plant diversity indices. The Core and Buffer zones of Marguba Range of Old Oyo National Park were assessed for their biological diversity in terms of fauna and flora, using a systematic sampling technique.

The floristic sampling followed systematic sampling method using the procedure of Olubode *et al*. (2011). A baseline transect of 3 km was laid along both the buffer (one) and core zone (two) (as observed during reconnaissance survey). Along the baseline transect, perpendicular transects were located at intervals of 250 m (Figure 3.3). A total of 12 perpendicular transects were situated in the buffer area and 24 in the core area. Each perpendicular transect was 300 m in length. Sampling plots of 20 m X 20 m were located at each side of the transects at intervals of 150 m using Garmin™ 12 etrex Vista H model GPS to separate each plot and they were laid perpendicularly to each other. A compass was used to guarantee precision in the direction of the points in the location, while a GPS was employed to identify and label distinct sample plots. Wooden pegs with orange ribbons were used to demarcate each of the points' boundaries. Therefore, a total of 36 and 72 sample plots were established in the buffer and core zones, respectively per season per year. Each plot's herbaceous flora was counted by randomly placing five 1 m X 1 m wooden square quadrats at five random points (four at the corners and one centre placed) of each 400 m^2 square plot. A total of 180 and 360 quadrats were laid to enumerate the herbaceous species in the buffer and core zones, respectively (Figure 3.4).

The woody flora was enumerated within each 20 m x 20 m plot. Thus, a total of 36 and 72 plots were laid to assess the woody species in the buffer and core zones, respectively. Haga altimeter was used to measure the tree height at a distance of 15 m, tree species ≥ 30 cm Girth at Breast Height (GBH) were measured using a measuring tape. Number of all species encountered were documented in a species X individual (entity) arrangement prior to analysis.

3.6.3 Data collection

Data on floristic composition within the zones was collected as follows:

3.6.3.1 Herbaceous and woody flora

1. Species were identified using visual knowledge and standard flora: Handbook of West African Weed by Akobundu *et al*. (2016) and Weeds of

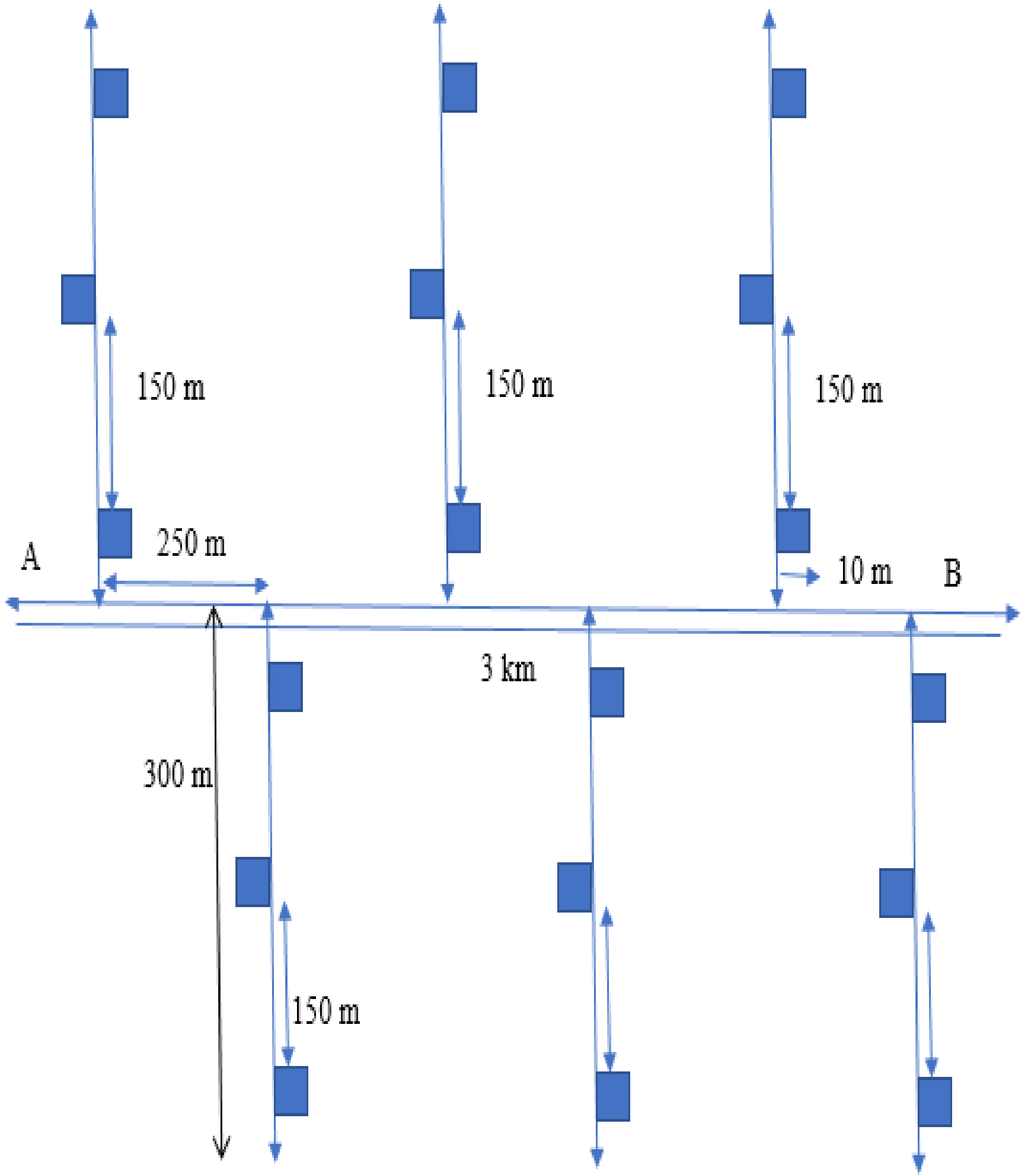

Figure 3.3. **Transect and plot design of the Core and Buffer zones (A to B shows baseline transect) ■ = 20 x 20 m plot**

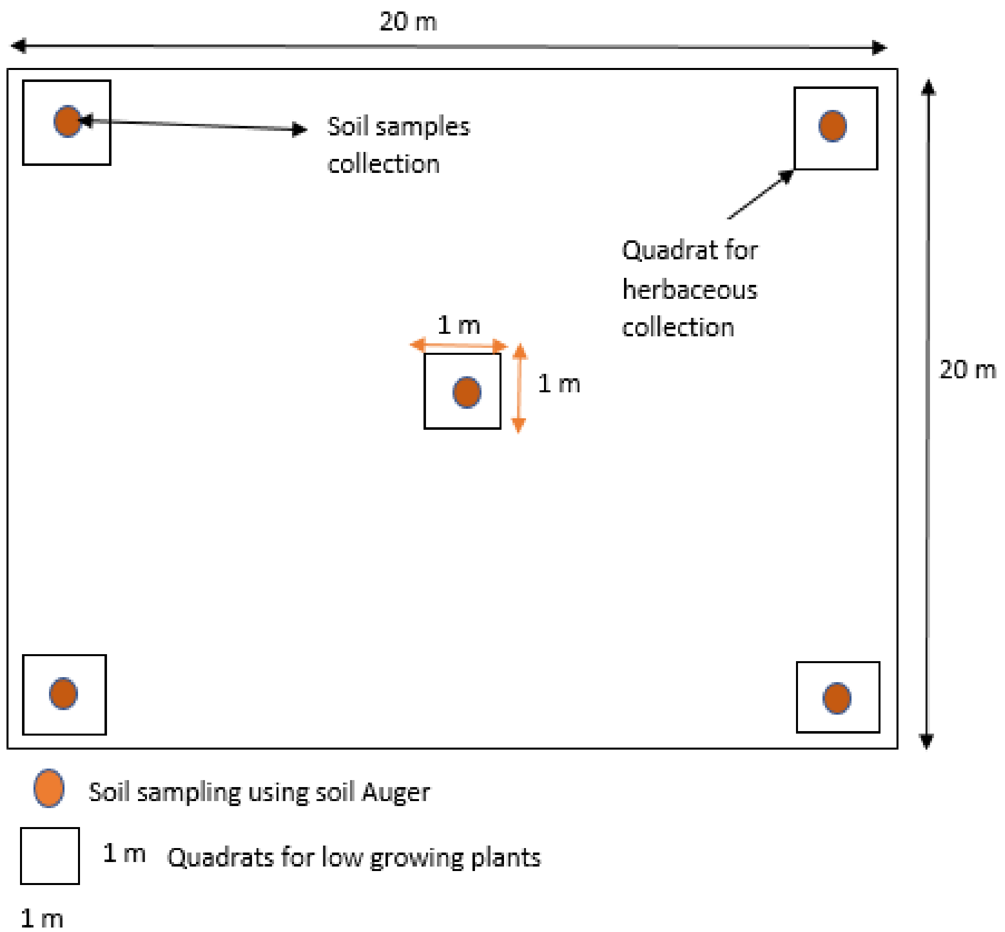

Figure 3.4. Plot layout of the sampled locations and associated parameters taken which includes the 1 x 1 m quadrat and soil sample collection at each point at the buffer and core zones of Marguba range of Old Oyo National Park in 2017-2018 and 2018-2019.

2. Rice by Johnson (1997) for herbaceous and West African trees by Keay *et al*. (1989) for woody species.
3. Count of flora (herbaceous and woody) in plots for abundance, frequency, density and diversity indices calculations.
4. The DBH and height of standing trees

3.6.3.2 Species identification and enumeration

The floristic survey was carried out during rainy and dry seasons. All plant species common to Buffer and Core zones were noted and an indicator plant species within each zone was identified at family and species level.

3.7 Soil sample collection for soil seed bank analysis

3.7.1 Soil samples collection

Soil samples were collected during the dry and wet seasons for two consecutive years, randomly from each quadrat in three plots along each transects (Figure 3.4). The top layer of undecomposed litter was scraped off and the soil samples were collected from the 0-15 cm depth according to the procedure of Traba *et al*. (2004). A Soil corer (cylinder) with a thickness of 7.5 cm was used to collect soil (0-15 cm) vertically and at a depth of 15 cm and put in plastic bags after the removal of litters, roots and other debris. All soil samples were air dried and kept in the dark environment until the soil seed bank experiment began.

3.7.2 Examining soil depth's correlation with seasonal germinability, density and composition of species in the seed bank of soils

Soil samples were collected from each plot (core and buffer zone) at depth (0-15 cm) and bulked for each perpendicular transect. They were collected in plastic bags, labelled and transported to the Ecology laboratory, Department of Crop Protection and Environmental Biology, University of Ibadan. Soil samples were air-dried for two weeks prior to enumeration in the screen house. Each zones's (Buffer and Core) soil samples, one kilogram each, were bulked and delivered to the Forestry Research Institute of Nigeria (FRIN) for standard soil analysis.

3.7.2.1 Soil seed bank enumeration and germination study

Following air-drying, the soil samples underwent manual cleaning to eliminate stones, pebbles, roots and coarse wood debris by hand. Using a digital weighing scale, one kilogram of each sample was measured and evenly spread across 36 and 72 (Buffer and Core zone) germination trays (10 x 4 cm). Germination trays were arranged randomly and placed in the screen house under semi-monitored conditions (**Plate *3.1***).

The germination trays were monitored daily and watered as necessary to keep the surface damp and to induce seed germination over a 120-day period. Soil seed bank enumeration was determined using germination method (Jiang *et al*., 2013). At two (2) weeks interval, emerged seedlings were identified, counted and removed (Oke *et al*., 2013). The seedlings that could not be named were tallied and transplanted onto different growth trays until they could be confirmed and identified.

The soil was upturned at two weeks' interval for 24 weeks during each season to bring the plant seeds from the base of the tray to the soil surface for new germination, and the experiment was terminated when no new growth was observed (Maclean *et al*., 2017).

Plate 3.1. **The experimental layout for the Soil seed bank study at the screen house of CPEB, University of Ibadan includes visual evidence of seedling growth**

3.7.2.2 Physical and Chemical characteristics of soil

- **pH:** A glass-electrode pH meter was used to measure the pH of the samples by making suspension with distilled water at a 1:1 mixture ratio of soil (2 mm) and distilled water (10 ml) (Mclean, 1982).
- **Organic Carbon:** Estimation of Organic carbon was done by following the Walkley and Black's rapid titration method as modified from Walkley and Black (1947).
- **Available Nitrogen:** Available nitrogen was calculated by adopting the alkaline permanganate technique of Subbiah and Asija (1956)
- **Available Phosphorus:** Estimation of available phosphorus was done by sodium bicarbonate extraction method using Spectrophotometer according to the method of Olsen (1982).
- **Exchangeable Potassium:** Estimation of exchangeable Potassium (K) was done using Flame photometer according to Isaac and Kerber (1971).
- **Particle size analysis:** This was done following the method of Day (1965), the percentage silt and clay in the soil was calculated by using hydrometer method.

3.8 Estimation of volume of carbon sequestration potentials of the standing vegetation in the Buffer and Core zones of the Marguba Range of Old Oyo National Park.

3.8.1 Data collection

A non-destructive sampling method of Valbuena *et al*. (2016) was employed to estimate the above-ground biomass. The published generic allometric equation of Brown *et al*. (1989) for dry tropics was used to estimate the carbon sequestration potential.

3.8.2 Field measurements

3.8.2.1 Carbon stock estimation

The field data consisted of 108 plots, data were taken towards the end of rainy season in the Buffer and Core zones of the Marguba Range of Old Oyo National Park when species could be easily identified. A 400 m^2 plot was used to sample each study location. Aboveground carbon estimates were based on the living tree species aboveground biomass. To calculate the aboveground biomass, all trees and shrubs with a girth ≥30 cm were identified, and their Diameter at Breast Height (DBH) was derived in all the sampled plots. The DBH was used to determine aboveground biomass using a model created by Brown *et al*. (1989). At 1.3 m height, trees and shrubs with several stems were taken as a whole, with the DBH of the largest stem recorded. The tree heights were measured using Haga altimeter at a 15 m distance and while DBH was determined with a meter rule.

3.9 Measurement of Plant community structure

Data were analysed using some software packages on Multivariate analysis following Johnson and Wichern (2002), and Diversity indices. PAST: Paleontological statistics version 2.14 software for classification and ordination was used following Hammer *et al*. (2001), DECORANA for numerical ordination and TWINSPAN for species classification were enumerated following the process described by Hill (2012).

3.9.1 Herbaceous/woody species analysis

This analysis followed the description of Kent and Coker (1992)

3.9.1.1 Species density

Density is the quantity of individual species to abundance of species per unit specified area. In this study, the density was calculated using 1 m^2 for herbs, 400 m^2 for trees and 0.4 m^2 unit for seed bank which were extrapolated to calculate the density per hectare following Eqn. 3.7

$$Density\ (D)\ = \frac{Total\ Number\ of\ individual\ Species\ in\ all\ quadrats}{Quadrat\ size\ X\ Number\ of\ quadrats\ laid} \ldots\ldots\ldots\ldots\ldots\ldots. Eqn. 3.7$$

3.9.1.2 Relative density of species

The density of one species as a fraction of the total density of all species encountered, which is usually presented in percentage. The relative density was calculated using Eqn. 3.8

$$Relative\ density\ (RD)\ = \frac{Density\ of\ a\ species}{Total\ density\ of\ all\ species}\ X\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots. Eqn. 3.8$$

3.9.1.3 Frequency of the species

This is a measure of the degree of uniformity in the species spatial distribution. It also connotes the number of occurrences of a species in a set of quadrat or area. It was calculated using Eqn. 3.9

$$Frequency\ (F)\ = \frac{Number\ of\ species\ occurence}{Total\ number\ of\ quadrats\ sampled} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. Eqn. 3.9$$

3.9.1.4 Relative Frequency

It gives a good idea of the degree of dispersion of a specific species in a specified unit area to the number of species normally present. This was estimated following Eqn. 3.10

$$Relative\ frequency\ (RF)\ = \frac{Frequency\ of\ Species}{Frequency\ of\ other\ Species}\ X\ 100 \ldots\ldots\ldots\ldots\ldots..Eqn. 3.10$$

3.9.1.5 Relative Importance Value of the species

The measure of comparative contribution of species to the entire community is its importance. This defines each species' overall relevance in the community. It was determined following Eqn. 3.11.

$$Relative\ Importance\ Value\ (RIV)\ = \frac{Relative\ Density + Relative\ Frequency}{2} \ldots Eqn. 3.11$$

3.9.2 Diversity Indices

The data collected from the quadrats was analysed for the Shannon-Wiener index, Equitability index, Dominance index, Evenness index and Jaccard similarity index.

3.9.2.1 Shannon-Wiener index

This is a method of calculating biodiversity by comparing the relative abundance and diversity of species occupying a community in a given area; it was calculated using Eqn. 3.12

$$Shannon\ Wiener\ (H') = -\sum_{i=1}^{s} pi(lnpi) \ldots\ldots\ldots\ldots\ldots\ldots\ldots..\ldots\ldots\ldots\ldots Eqn. 3.12$$

Where H′ is Shannon-Wiener; pi=ni/N; For species i, ni is the number of independent flora species present., N is the total number of individuals, S is the species count in each community and Ln is the natural logarithm. The value ranges between 0 to 4.6, with 0 denoting a specific individual dominating, while high values indicate high species diversity (Awodoyin *et al*., 2013).

3.9.2.2 Equitability index

This represents the species evenness within groups of species depicting the mode of distribution of species and it was calculated following Eqn. 3.13

$$Equitability\ index\ (J) = \frac{H'}{InS} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eqn. 3.13$$

Where J is the equitability index, H′ is Shannon-Wiener index, S is the species count in each community, Ln is the natural logarithm. The value varies between 0 and 1. When individual species tend towards 1, it means they are evenly distributed, and towards 0 means one or two species is dominating that community.

3.9.2.3 Dominance index

This is a measure of how common a species is in comparison to other species in an ecosystem. It ranges from 0 to 1, where values that tend towards 1 show one species dominates the community. It was calculated using Eqn. 3.14

$$Simpson\ index\ of\ Dominance\ (D)\ = -log \sum_{i=1}^{s} pi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eqn. 3.14$$

Where D is the dominance, s is the species richness of a community, pi is the relative proportion of species i.

3.9.2.4 Similarity index

The Jaccard index of similarity (J) was employed to estimate the composition of species similarity amongst location and seasonal changes in addition to seed bank present in the soil and above ground flora. This was calculated using Eqn. 3.15

$$Jaccard\ similarity\ index\ (SCj)\ (\%)\ = \frac{W}{D+E-W}\ X\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eqn. 3.15$$

Where W signifies the species number that are common in both communities D and E, D signifies the species number in community D, and E signifies the species number in community E. The percentage ranges from 0% (no resemblance) to 100% (complete resemblance) (Maximum similarity). The sites were compared pair by pair, and a matrix of similar community index values was created (Awodoyin *et al.,* 2013).

3.9.3 Tree parameters analysis

3.9.3.1 Tree Diameter at Breast Height

This was determined by converting measured Girth at Breast Height (GBH) to DBH using the formulae in Eqn. 3.16 by Hairiah *et al*. (2010).

$$DBH = \frac{GBH}{\pi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eqn. 3.16$$

3.9.3.2 Tree height

Tree height (H) was measured using Haga altimeter for each individual tree at a varying distance (15 m, 20 m) from the tree. It was calculated using Eqn. 3.17

$$Height\ (m)\ = \frac{Top\ reading - Bottom\ reading}{Distance}\ X\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . Eqn. 3.17$$

3.9.3.3 Basal Area determination

Basal area is determined by measuring the cross-sectional thickness of the tree trunk at 1.3 m above the ground (breast height). The basal area was calculated using Eqn. 3.18

$$\text{Basal area (BA)} = \frac{\pi D^2}{4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eqn. 3.18}$$

Where π = 3.14, D = Diameter of the tree species (Adekunle *et al.*, 2014)

The total basal area was obtained by adding the basal area of all tree species in the plots

$$Relative\ Dominance = \frac{Total\ Basal\ area\ of\ a\ species}{Total\ basal\ area\ of\ all\ species}\ X\ 100$$

3.9.3.4 Importance Value Index (IVI)

The sum of relative values of frequency, density, and basal area was used to estimate the IVI (Phillips, 1959) as seen in Eqn. 3.19

Phillips (1959) developed the Importance Value Index (IVI) as a way to quantify every species' dominance and ecological effectiveness with a single number. It is a weighted sum that reflects the abundance and ecological effectiveness of any species.

$$Importance\ Value\ Index\ (IVI) = Relative\ Density + Relative\ Frequency + Relative\ Dominance \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . Eqn. 3.19$$

The dominant species is the species with the highest IVI in the site, whereas the rare/least dominating species is the species with the lowest IVI. Where IVI ranges from 0 to 300

3.9.4 Biomass estimation and Carbon stock

The above-ground biomass of each woody species was calculated using the allometric equation (dry weight, kg). The use of an appropriate allometric equation for biomass estimate is critically important for reducing inaccuracies (Djomo *et al*., 2016). The allometric equation developed by Brown *et al*. (1989) was used because it was designed for dry tropical trees with annual rainfall >900 mm which is applicable to the study area. Using the documentation of Garzula and Saket (2003) on wood volume and biomass, a non-destructive approach was utilized to calculate the biomass of each tree species. The general allometric equation in Eqn. 3.20 was employed.

$$AGB = \exp\{-1.996 + 2.32\ x \ln(DBH)\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . . Eqn. 3.20$$

Where exp= exponential, Ln is the Natural Logarithm, DBH = Diameter at breast height, AGB is the above ground biomass.

Estimation of aboveground carbon content

$$AGC = AGB\ X\ 0.5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eqn. 3.21$$

where, AGC is above ground carbon content and AGB is above ground biomass

The quantity of CO_2 sequestered in aboveground biomass was calculated by multiplying the aboveground carbon by 3.67. Because the CO2/C ratio is (44/12) = 3.67.

The conversion of above-ground biomass to carbon stock was then done using a conversion coefficient of 0.47, as suggested by the IPCC (2006).

3.9.5 Method of Data Analysis

Soil data for buffer and core zone were tested using Analysis of Variance (ANOVA) to compare the variances among the samples and to determine the significance of the sample means. Furthermore, Post-hoc test analysis was done using Least Significance Difference (LSD) test to find out the homogeneous subsets among the sites. Statistical tests were performed at 0.05 significant level.

CHAPTER FOUR

RESULTS

4.1 Respondents' demographic characteristics

The mean age of respondents was 30.74 ± 7.05 years, the respondents were of the productive age i.e., young adults and they ranged between 21-40 years while the aging group (41-50 years) were 10.7% of respondents. The minimum age of respondents was 20 years, and the maximum was 50 years (Table 4.1). Majority (69%) of the respondents were male while females constituted (26%). Seventy-five percent of respondents were married with 2.4% divorced. Majority (55.9%) of the respondents had household size of 4-6, while household sizes 1-3, 7-10 and >10 constituted 13.1%, 3.1% and 1.4% of the respondents, respectively. With a mean household size of 4.20. The village with the highest number of respondents was Imodi (26.2%) while Oke-odoogun (6%) had the lowest number of respondents (Table 4.1). The level of education was low with 50% of the respondents without formal education, only one (1) respondent had tertiary education and 27.4% had primary education but 21.4% attained secondary education (Table 4.1).

4.1.1 Enterprise characteristics of respondents

Most (45.2%) of the respondents owned 11-15 farmlands while only 6 respondents (7.1 %) owned more than 20 farmlands. The mean value of 2.93 ± 1.06 implies that most of the respondents had more than 2 farmlands (1-5 farmlands). Most respondents (85.7%) had farms that were 1-3 km away from their households while only one (1.2%) respondent had his farm 4-6 km away from his household. The mean value of 1.01 implies that the respondents had their farms 1-3 km away from their household (Table 4.2). The major source of income was farming (35.7%), while Hunting (13.1%) was the least source of income indicated (Table 4.2).

Table 4.1. Distribution of respondents based on selected personal characteristics in the study area in OONP, Nigeria

Variables		Frequency	Percent	Mean ± SD
Age	11-20yrs	3	3.6	
	21-30yrs	44	52.4	
	31-40yrs	28	33.3	30.74 ± 7.047
	41-50yrs	9	10.7	
Gender	Female	26	31	
	Male	58	69	
Marital status	Married	63	75	
	Widowed	3	3.6	
	Single	16	19	
	Divorced/separated	2	2.4	
Household size	1-3	11	13.1	
	4-6	47	55.9	4.20 ± 0.673
	7-10	26	31	
	>10	1	1.4	
Village/Town	Abanla	15	17.9	
	Oke-odoogun	5	6	
	Kanga	15	17.9	
	Budo egede	8	9.5	
	Alapata	7	8.3	
	Imodi	22	26.2	
	Ajirowo	12	14.3	
Educational status	Primary education	23	27.4	
	Secondary education	18	21.4	
	Tertiary education	1	1.2	
	No education	42	50	

SD = Standard deviation

Table 4.2. Distribution of respondents based on their enterprise characteristics in the study area in OONP, Nigeria

Variables		**Frequency**	**Percent**	**Mean ± SD**
Total farmland owned	1-5	10	11.9	
	6-10	14	16.7	2.93 ± 1.062
	11-15	38	45.2	
	15-20	16	19	
	>20	6	7.1	
Distance of Farm to household	1-3km	72	85.7	
	4-6km	1	1.2	1.01 ± 0.117
	>6km	11	13.1	
Sources of Income	Civil servant	13	15.5	
	Teaching	11	13.1	
	Farming	30	35.7	
	Trader	18	21.4	
	Artisan	12	14.3	

S.D. = Standard deviation

4.1.2 Correlation of knowledge and perception on use of trees

The PPMC result (Table 4.3) of relationship between respondents' knowledge of importance of trees in the Park and attitude to use of trees for fuelwood was not significant. There was a positive correlation (r=0.173) between farmers' knowledge and fuelwood use, however, there was a negative correlation (r=-0.192) between farmers' perception of importance of trees and use of trees for fuelwood but there was no significant relationship between these attributes because as the attitude of the respondents to use of trees as fuelwood use increases, their perception of its use decreases and vice-versa (Table 4.3).

The t-test analysis showed that there was a significant difference between respondents' use of wood for charcoal and firewood with good preference for firewood (Mean=5.08) than charcoal (Mean=2.82) as presented in Table 4.4 and Table 4.3.

4.1.3 Selected trees harvested by respondents and the purpose of harvest in the farms around Old Oyo National Park

Tree species were harvested for different purposes which were fuelwood (Table 4.5) and medicinal purposes. Majority of the respondent uses the trees harvested for firewood (49.8%) and medicine (43.6%) while only a few respondents indicated they process it to charcoal (6.5%) before use. *Daniella oliveri* was mostly harvested for firewood, *Azardirachta indica* for medicine, while *Kigelia africana* was the least harvested tree for charcoal production (Figure 4.1).

4.2 People's perception and view of the Park's management

There were 10 participants in this category which included 7 farmers and 3 park workers (Research officers/Park official). Amongst the 7 farmers, there were 3 participants within the age group 31-40 years, 2 in age group 41-50 years and 2 in the age group (21-30 years). Five (5) of the respondents were male (50%) and two (2) females (20%). The Park workers were between ages 31-50 years and all male (30%)

4.2.1 Perception on relationships between Park workers and Farmers around the Park

Only 3 respondents of the 7 (43%) felt a positive relationship with park rangers and guards, 3 were neutral while only one respondent noted a negative relationship exist between the park rangers and the communities surrounding the park. The research officers noted a positive relationship between them and the communities.

Through the interview:

Table 4.3. PPMC results of relationship between respondents' knowledge, attitude and use of trees for firewood and charcoal

Independent variable	R	P	Remark
Knowledge	0.173	0.115	NS
Perception	-0.192	0.081	NS

*R- Correlation, P- Probability, NS- Not significant

Table 4.4. Level of behavioural attributes of respondents, their perception to fuelwood uses in the study area

Levels	F	%	Mean	SD	Minimum	Maximum
Knowledge			35.8810	14.53985	0.00	66.00
High	50	59.5				
Low	34	40.5				
Perception			81.6190	5.93171	62.00	104.00
Favourable	44	52.4				
Unfavourable	40	47.6				
Charcoal			2.8214	3.57082	0.00	10.00
High	28	33.3				
Low	56	66.7				
Firewood			5.0833	4.19756	0.00	10.00
High	46	54.8				
Low	38	45.2				
Medicine			7.9048	7.06360	0.00	19.00
High	46	54.8				
Low	38	45.2				

F- Frequency, %- Percentage, SD- Standard deviation

Table 4.5. T-test analysis of the difference between respondents' use of Wood for Charcoal and Firewood

Group	**Mean**	**N**	**SD**	**T**	**df**	***P* value**	**Decision**
Firewood	5.0833	84	4.19756	6.295	83	0.000	Significant
Charcoal	2.8214	84	3.57083				

N – Number, SD – Standard Deviation, T – t-test, df – Degree of freedom, P - Probability

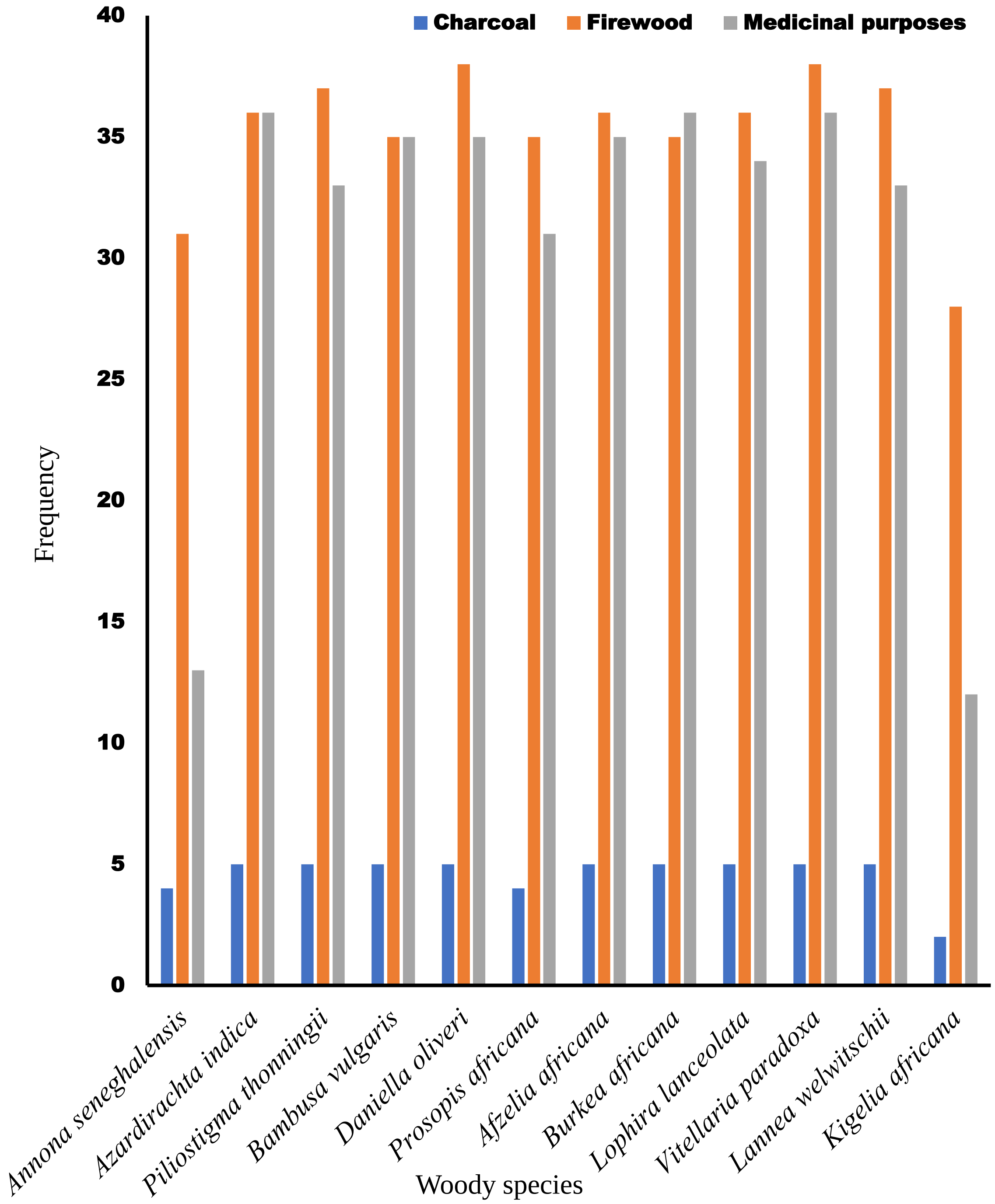

Figure 4.1. **Frequency of harvested woody species and the purpose of harvest in the villages surrounding the Marguba Range of Old Oyo National Park.**

> A participant reported that Park officials had positive rapport with the villagers as some of them are warm towards them sometimes by entertaining them and giving them food, they see us as counterparts in the management of the park and so are very lively in relating with us **(IDI, Local farmer, Male, 46, Old Oyo National Park, 2019)**

A park worker also aired his view saying:

> *The people in the communities are very friendly, especially the men, they gist with us and wants to know what is on ground as it relates with park management* **(IDI, Park official, Male, 35, Old Oyo National Park, 2019)**

In general, there is a positive relationship between the perception of the community dwellers and the park workers about how they relate with each other.

4.2.2 Perceptions on conflicts and its sources

Six (86%) of the respondents believed (it was thought) that there were tensions between the communities and the park management. They pointed out that their lands were forcefully taken away from them which means there is no way they could farm to feed their family sustainably, adding to the fact that they were not properly educated in the area which makes farming activities the next best option.

Restricted access to the park for resource extraction, limited community development opportunities, lack of employment to deserving persons. While park workers noted that the communities were well informed and compensated before the takeover, and as the years goes by, they argued that the administration has been carrying the community along with their dealings, although One (33%) believed that the park management has not been sufficiently consulting the communities in the running of the park.

4.2.3 Land takeovers

Through the interview:

> *A participant reported that the land he got from his father was located close to the National Park and therefore he was asked to vacate, making his access to land more difficult owing to unavailability of land* **(IDI, Local farmer, Male, 42, Old Oyo National Park environs, 2019)**

Another farmer noted that:

Wild animals make it difficult for me to have a high yield (especially monkeys and giant rats), they come into my farm even with all the scarecrow I have to destroy my crops. They uproot maize or cassava **(IDI, Local farmer, Female, 34, Old Oyo National Park, 2019)**

A park guard noted that:

It was difficult getting the people to leave their farmlands, the government held a part of their bargain by employing some of us but a greater number are still suffering because their families depend on them for daily provision of food **(IDI, Park official, Male, 30, Old Oyo National Park, 2019)**

4.2.4 Restricted access to Park for resource extraction

All Seven (100%) of the respondents interviewed said extraction of resources from the park was totally restricted and that during the dry season, fire outbreaks and sometimes affected farmlands, especially those close to the Buffer zone. They also expressed concern that this reduced the amount of fodder available to wild animals. A park worker confirmed that this was the cause of the dispute:

There was a time the people forcefully entered the park to extract resources, destroyed a lot of biodiversity even including the Buffer zone signpost (which could mean they don't want to be restricted or that the land available to them is now marginalized and they wanted access to their ancestral lands) **(IDI, Park official, Male, 34, Old Oyo National Park, 2019)**

Although Park officials blamed the communities for fire outbreaks as some of them still used the old-fashioned system of luring animals from holes and hide outs. Park workers also reported that they limited community access to the park due to concerns about harvesting of endangered plants species and poaching of wild animals. This demonstrated a strong lack of mutual trust between park staff and local dwellers.

The farmers also reported that

Some Park workers go in and extract resources and then sell to us at expensive prices in our community market because the culturally important medicinal plants we depend on are found inside the Park **(IDI, Local farmer, Female, 29, Old Oyo National Park, 2019)**

In these communities, many poor households depend on natural resources as their main source of livelihood, as they are denied access, it further strengthens the conflictual relationships and negative attitude towards the park workers.

> My wife sells firewood, all these trees that are good sources of fuel are no longer available in our community and we have a limit of where we can get to take this material, therefore, life becomes very hard because I am the only bread winner in the family which is not enough to cater for our six children **(IDI, Local farmer, Male, 43, Old Oyo National Park, 2019)**

4.2.5 Limited community development opportunity

Four of the respondents (57%) indicated their dissatisfaction with the park management, citing that the communities around the Range were in poverty, their children could not go to school because teachers attended schools whenever they felt like, they claimed they had no good water supply, they usually trekked far distances before they could get drinkable water, the roads to their farms were bad and not motorable except one had a motor bike in good working condition. This claim was corroborated by a park official as a source of conflict who also said:

> The schools that are government owned are sometimes closed and you see children playing around on the roads, they lack staff, likewise, there is no access to good water supply which could mean frequent visit to health care centre which is also very far from some of the communities **(IDI, Park official, Male, 33, Old Oyo National Park, 2019)**

Although, these changes were sometimes due to change of management regimes, roads were graded whenever the management deemed it fit but that had to come from a higher authority, some management teams were very responsive to community development projects while some were not. Therefore, he concluded that the park's management was no longer benefiting the neighbourhoods through community development projects.

Another respondent was indifferent about community development, stating explicitly that they were aware that the primary mandate of the management was to conserve biodiversity and curb anything that was against it while claiming that community development could be hampered by lack of funds from the government.

4.2.6 Lack of employment for deserving persons

Four of the respondents believed that lack of employment was one of the causes of the conflict with Park management. They further stated that even though employment opportunities were one of the things Park managements promised them, they were not taking in enough numbers from their communities. His statement:

> We are aware that there are limited job opportunities, but these are often offered to outsiders rather than the locals, they are not as skilled as us as we are more used to the terrain of the park and know the likely poachers and their routes but instead outsiders are favoured over us **(IDI, Local farmer, Female, 29, Old Oyo National Park, 2019)**

However, not supporting this were two park officials who stated that they were members of these communities and got the job because of that, they pointed out that the locals were the first to be considered for the job but several them lacked the skills or even the education to be offered the available position, saying:

> *There are certain skills and education needed for these positions which might not be available amongst the locals and therefore, they tend to complain about the system of selection of the candidates for the position* **(IDI, Park Official, Male, 31, Old Oyo National Park, 2019)**

4.2.7 Non engagement of the local residents in management issues regarding the park

The locals believed they were not engaged when it comes to the management of the park, and this was regarded as a potential source of conflict by four (57%) of the respondents. They stated that they were not well informed when there were positions to be taken up, no information as to when management was changing, there was no platform where they could air their views about the state of the park-

> The only thing we know about were the things we were told when the park came to be, this information was passed down from generation to generation and it is what we still discuss during meetings. Generally, we are not well informed as stake holders of the park. The people that

> get more information about the park do not even stay close to the park or have their farmlands in these vicinities, we are the ones affected by these decisions and we are the last to hear any news **(IDI, Local farmer, Female, 40, Old Oyo National Park, 2019)**

The Park officials had a disparate view of the gap in knowledge, they were of the opinion that the farmers believed whatever was going on with the Park should be disseminated to them from household to household, there are platforms available for this purpose. There are fora that were directly informed, and they are to relay the information to the rest of the farmers by means we might not be aware of. The local farmers and Park personnel gave slightly differing views which resulted in negative relationships between them.

4.2.8 Human and wildlife conflicts

About 5 of the respondents were bitter about the situation of wildlife on their farmlands. This generated conflict because, they were not compensated for whatever loss they incurred on their farmlands saying

> The damage from wildlife is very much, we report to park workers, but we see there is nothing that can be done as the park is not fenced so the animals are at liberty of moving around, we had to resolve to setting traps on our farmlands and we must confess, it traps some animals, and we sell at the village market. Sometimes we don't and that means we just bare the loss and no incentives from the government. A respondent highlighted that he sometimes decides to sleep on his farm because of monkeys and killing whichever he is able to **(IDI, Local farmer, Male, 42, Old Oyo National Park, 2019)**

A park official reported that as much as they would like to curb this situation, it was beyond them. The locals truly complained about animals causing destruction on their farms, but that they kept encouraging them not to resolve to killing the animals, and embrace conservation instead. He was quoted saying:

> The locals that have farms close to the buffer zone were trained as the animals were dwindling in numbers, we told them their farmlands were around a national park and the

> park is not fenced which means the animals are liable to go from one location to another in pursuit of food, they complained bitterly about the menace, but we could only encourage them not to resolve to killing the animals" **(IDI, Park official, Male, 42, Old Oyo National Park, 2019)**

There is a positive relationship and mutual understanding between the locals and park officials; however, the locals hated the park officials for moving them from the buffer zone. Conflict still existed with the wild animals.

4.3 Weather attributes of the Buffer and Core zones of the Marguba Range of Old Oyo National Park

4.3.1 Average Maximum temperature

The average maximum temperature of the Buffer and Core zone had a fluctuating pattern. The maximum temperature (32.1°C) was observed in 2016 and the minimum temperature (30.7°C) was observed in 2018 in the Buffer zone as against the core zone with Maximum temperature (31.1°C) in 2016 and minimum temperature (29.65°C) in 2018. The temperature relation of the buffer and core zone is by the linear equation Y=0.016x (99%) and 0.015x (99%), respectively which showed the annual temperature is directly proportional to the year. For every unit increase in year, the annual average temperature also increases by x=0.016 in buffer zone and x=0.015 in the core zone. The buffer zone recorded a relatively higher temperature than the core zone (Figure 4.2).

4.3.2 Average Precipitation

Maximum rainfall pattern (1950 mm) in the core zone was observed in 1995 while the minimum precipitation (934.19) was observed in 2005. In the buffer zone, the maximum precipitation (1460.16) in 2012 and the minimum (787.9) in 2005. Buffer zone had relatively low rainfall pattern compared to the core zone. The linear relationship of the buffer and core zone is Y=0.58x (R^2= 98%) and 0.69x (98%), respectively which showed the average precipitation is directly proportional to the year. For every unit increase in year, the annual average precipitation also increases by x=0.58 mm in buffer zone and x=0.69 mm in the core zone. The buffer zone recorded a relatively low rainfall pattern compared to the core zone (Figure 4.3).

4.3.3 Average Relative humidity

Highest relative humidity (80.8%) in the core zone was observed in 2013 while the lowest relative humidity (74.2%) was observed in 2016. In the buffer zone, the highest relative humidity (76.12%) in 1996 and the minimum (66.0%) in 2002. Buffer zone had relatively low relative humidity compared to the core zone. The linear relationship of the buffer and core zone is Y= 3.64x (R^2= 76%) and 3.96x (R^2= 77%), respectively which showed the average relative humidity is directly proportional to the year in the buffer zone and indirectly proportional to the year in the core zone. For every unit increase in year, the annual average relative humidity also increases by x=3.64% in buffer zone and x=3.96% in the core zone (Figure 4.4).

4.4 Assessment of accuracy of classification of Landsat images

The accuracy of all the classification dates is shown on Table 4.6. All the five classification dates had satisfactory overall accuracies of 85.9% in 1990, 87.2% in 2000, 80.2% in 2010 and 88.9% in 2019. The lowest accuracy score in 1990 was observed in Bare surface/Rocky outcrop with 78.5% of pixels being correctly classified. The wetland land use type also achieved 80.2% score of accuracy (as some pixels were incorrectly classified because they were not clear enough at the resolution used. In 2000, similar trend was observed as Bare surface/Rocky outcrop and wetland recorded relatively low accuracy scores of 78.9% and 81.2%, respectively. There was a little bit of confusion between bare surface and shrubland. In 2010, the lowest accuracy was observed in built-up areas (87.6%). In 2019, the lowest accuracy score was recorded in Shrubland /Grassland (81.4%), although the score was satisfactory (Table 4.6).

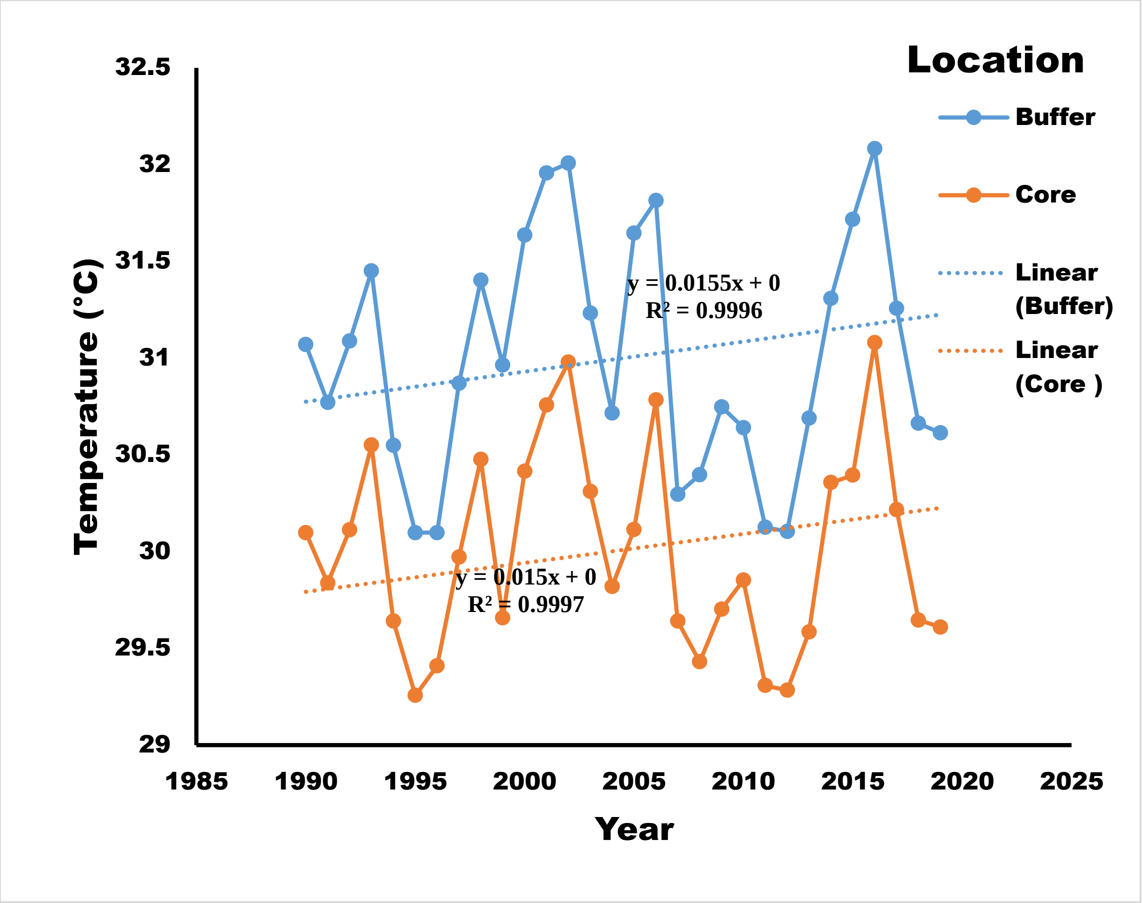

Figure 4.2. **Temperature (°C) of the Buffer and Core zone of the Marguba Range of Old Oyo National Park from 1990 - 2019**

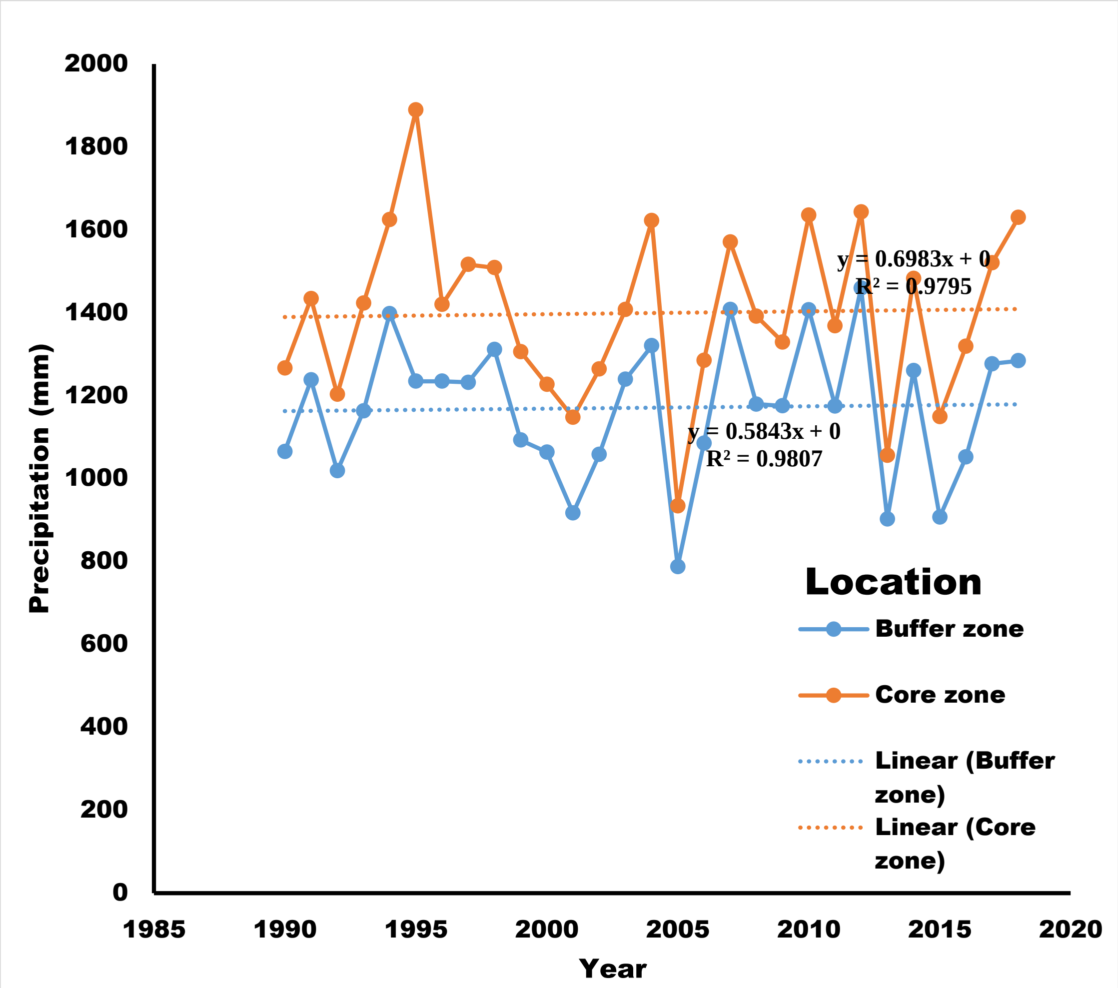

Figure 4.3. **Precipitation pattern (mm) of the Buffer and Core Zone of the Marguba Range of Old Oyo National Park from 1990 - 2019**

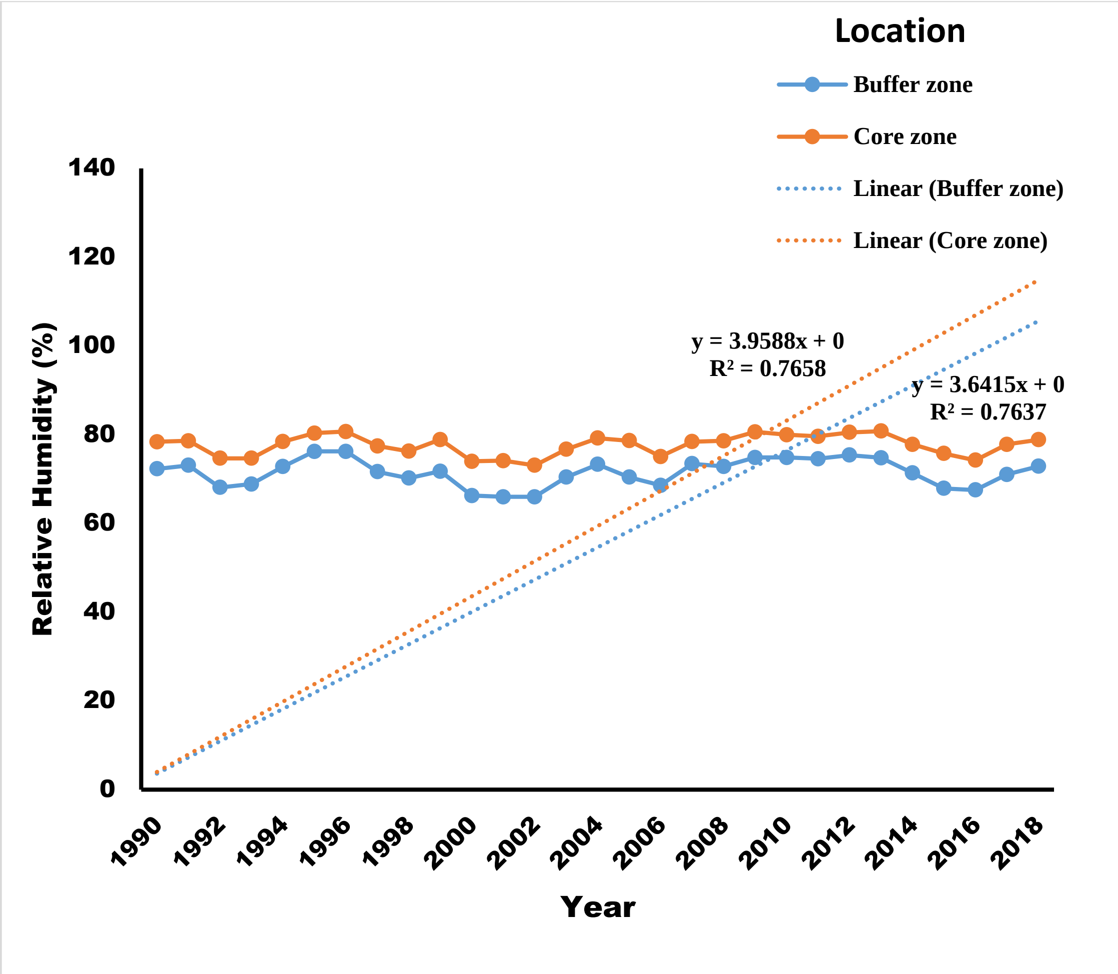

Figure 4.4. **Relative humidity (%) of the Buffer and Core Zone of the Marguba Range of Old Oyo National Park from 1990 - 2019**

Table 4.6. Classification accuracy assessment derived from the land use classes from 1990 - 2019

LULC types	1990		2000		2010		2019	
	User (%)	Kappa	User (%)	Kappa	User (%)	Kappa	User (%)	Kappa
Forest	95.7	0.947	98.5	0.968	99.2	0.982	100	1
Wetland	80.2	0.753	81.2	0.831	87.6	0.856	89.1	0.789
Shrubland/Grassland	89.5	0.901	90.1	0.893	92.1	0.905	81.4	0.832
Bare surface/Rocky outcrop	78.5	0.721	78.9	0.751	89.5	0.865	85.3	0.841
Overall	85.9	0.831	87.2	0.861	80.2	0.901	88.9	0.879

LULC – Land use/ Land cover

4.4.1 Status of land use/land cover at different periods

4.4.1.1 Trend of Land use/Land cover changes from 1990-2019:

The total area was 83,980 ha, 84,050 ha, 83,080 ha, and 84,520 ha in 1990, 2000, 2010 and 2019, respectively (Table 4.7). Shrub/Grassland had the highest land cover in 1990 (40,870 ha), 32,890 ha in 2000, 38,300 ha in 2010, however, in 2019, bare ground/rocky outcrop had the highest cover of 37,640 ha, while built-up had the lowest land cover in 1990 (940 ha), 2000 (1,870 ha), and 2, 970 ha in 2019, however, wetland had the lowest (1,980 ha) land cover in 2010 (Table 4.7). Four land use/land cover classification maps were generated for each year accessed (Figure 4.5 – Figure 4.8).

4.4.1.2 Rate of LULCC in the Marguba Range of Old Oyo National Park

An overall land use change that occurred from 1990-2019 was obtained from Landsat 8. Generally, between the periods of 1990-2019, a net loss was recorded in the shrub/grassland with 724.83 ha/year (0.9%) of area lost, and the Bare ground/Rocky outcrop gained an area of 543.10 ha/year (0.64%) which is the highest gained land area with the least land area gained recorded in wetland (7.93 ha/year (0.01%)) (Plate 4.1 and Plate 4.2).

There was land area increase in hectarage of bare ground/rocky outcrop with 861.00 ha/year (1.02%) between 1990-2000, however, between 2000-2010, it lost 790.00 ha/year of its land area which was later gained in 2010-2019 (1671.11 ha/year). After the 1990-2000 period for forest (264.00 ha/year (0.32%)), there was a fluctuation and it increased between 2000-2010 and 2010-2019 at a rate of 393.00 ha/year and 251.11 ha/year, respectively. The shrub/grassland lost an area of 798.00 ha/year in its first period but gained 541.00 ha/year in its second period and fluctuated again in its third period losing 2050.00 ha /year (Table 4.8).

4.4.2 Vegetation cover of the Buffer and Core zone of the Marguba Range of Old Oyo National Park

In 1990, the vegetation cover ranged from 0.48 to -0.33 with more forest cover and understory vegetation observed in both the buffer and core zones, However, the buffer zone had sparser vegetation (Figure 4.9). The vegetal cover changed in year 2000 with vast area lost and the values ranging from 0.06 to -0.36 which was the lowest during the period. The vegetation cover reduced vastly in both the buffer and core zones with sparser vegetation being observed (Figure 4.10). In 2010, low NDVI values were observed (0.42 to -0.19) although, high values were recorded in the core zone while the buffer zone had sparser vegetation (Figure 4.11). In 2019, the values were positive and ranged from 0.36 to 0.05 (Figure 4.12). Generally, low NDVI values were observed throughout the studied years ranging from 0.48 to -0.19.

4.4.3 Taxonomy and Species composition of the herbaceous species in the Buffer and Core zones of the Marguba Range of Old Oyo National Park

A total of ninety-three (93) herbaceous species in thirty-one (31) families were encountered in the five hundred and forty (540) quadrats laid for the floristic evaluation of the buffer and core zones in the wet season of 2017-2019. Fifty-seven (57) and forty-two (42) herbaceous species were encountered in the Buffer zone in the first and second wet season, respectively (Table 4.9). Sixty-eight (68) and forty-eight (48) herbaceous species were encountered in the Core zone in the first and second wet season respectively. Six (6) and Eleven (11) species were encountered in the first and second dry season in the Buffer zone. Nine (9) and Ten (10) species were observed in the Core zone in the first and second dry seasons, respectively.

The family Fabaceae was the most common family encountered in both Buffer and Core zones of the Marguba Range of Old Oyo National Park recording Seventeen species followed by family Poaceae (16 species), while family Amaranthaceae, Asparagaceae, and Azollaceae recorded one species each. Families Cyperaceae, Balanophoraceae, Connaraceae, Oxalidaceae, Loganiaceae, Typhaceae, Athyriaceae, Sphenocleaceae were only present in the Buffer zone while families Smilacaceae, Lythraceae, Pedaliaceae, Convolvulaceae, Onagraceae and Apiaceae were only present in the Core zone.

The herbaceous species in the Buffer zone had the highest number of families (Table 4.9). Thirteen (13) species were found to exist only in the buffer zone, and they include – *Thonningia sanguinea, Brysocarpus coccineus, Calopogonium mucunoides, Biophytum petersianum, Senna obtusifolia, Eriosema psolaroides, Sphenoclea zeylanica*, *Pueraria phaseoloidess*, *Crotalaria macrocalyx*, *Typha australlis, Sida rhomboidea*, *Manihot esculentus* and *Ageratum conyzoides*. Core zone had the highest number of species that were peculiar to the zone – eighteen (18): *Ludwigia octavalvis, Ipomoea aquatica, Sesamum indicum, Euphorbia hyssopifolia, Ammania baccifera, Echinocloa pyramidalis, Smilax anceps, Centella asiastica, Zingiber officinalis, Panicum brevifolium, Panicum repens, Desmodium velutinum, Sida acuta*, *Synedrella nudiflora, Asystasia gangetica, Vernonia galamensis, Phyllanthus niruri* and *Hyparrhenia rufa* (Table 4.9).

Table 4.7. Land use classifications of the Marguba range of Old Oyo National Park from 1990-2019

LULC classes	1990		2000		2010		2019	
	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%
Forest	16610	19.8	13970	16.6	17900	21.6	20160	23.9
Bare surface /Rocky outcrop	21890	26.1	30500	36.3	22600	27.2	37640	44.5
Wetland	3670	4.4	4820	5.7	1980	2.4	3900	4.6
Shrubs/Grassland	40870	48.7	32890	39.1	383	46.1	19850	23.5
Built-up	940	1.1	1870	2.2	2300	2.8	2970	3.5
Total	83980	100	84050	100	83080	100	84520	100

LULC–Land use/Land-cover

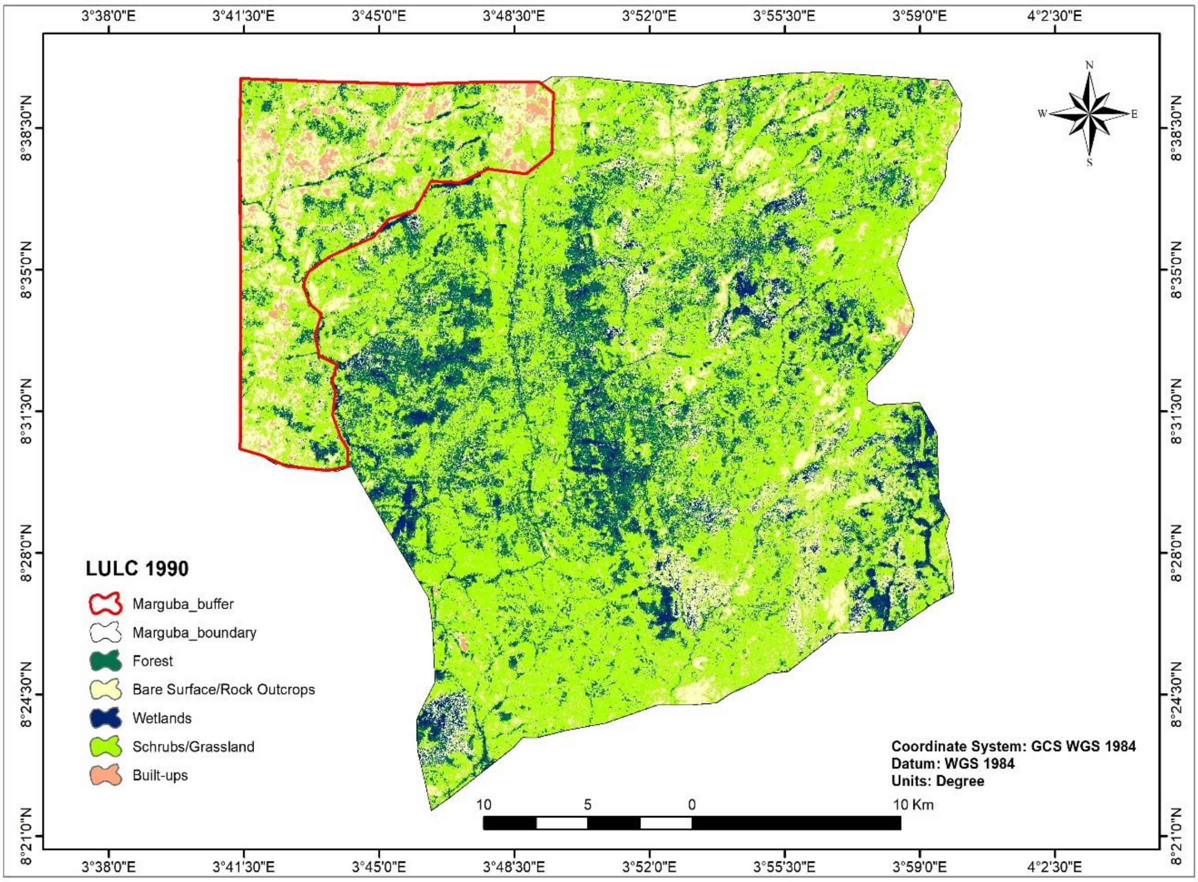

Figure 4.5. Map of Land use/Land cover of Buffer and Core zones of the Marguba range of Old Oyo National Park in 1990

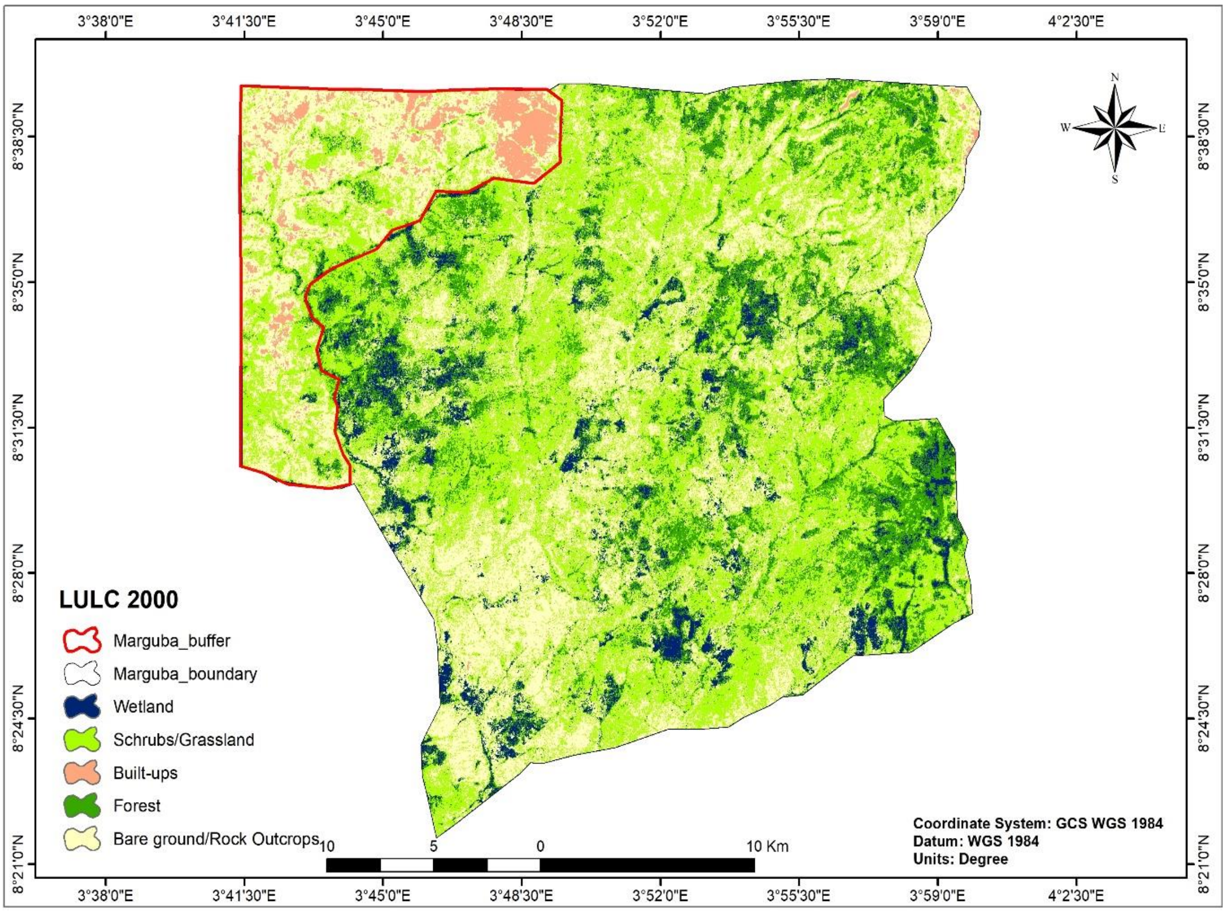

Figure 4.6. **Map of Land Use/Land Cover of Buffer and Core zones of the Marguba range of Old Oyo National Park in 2000**

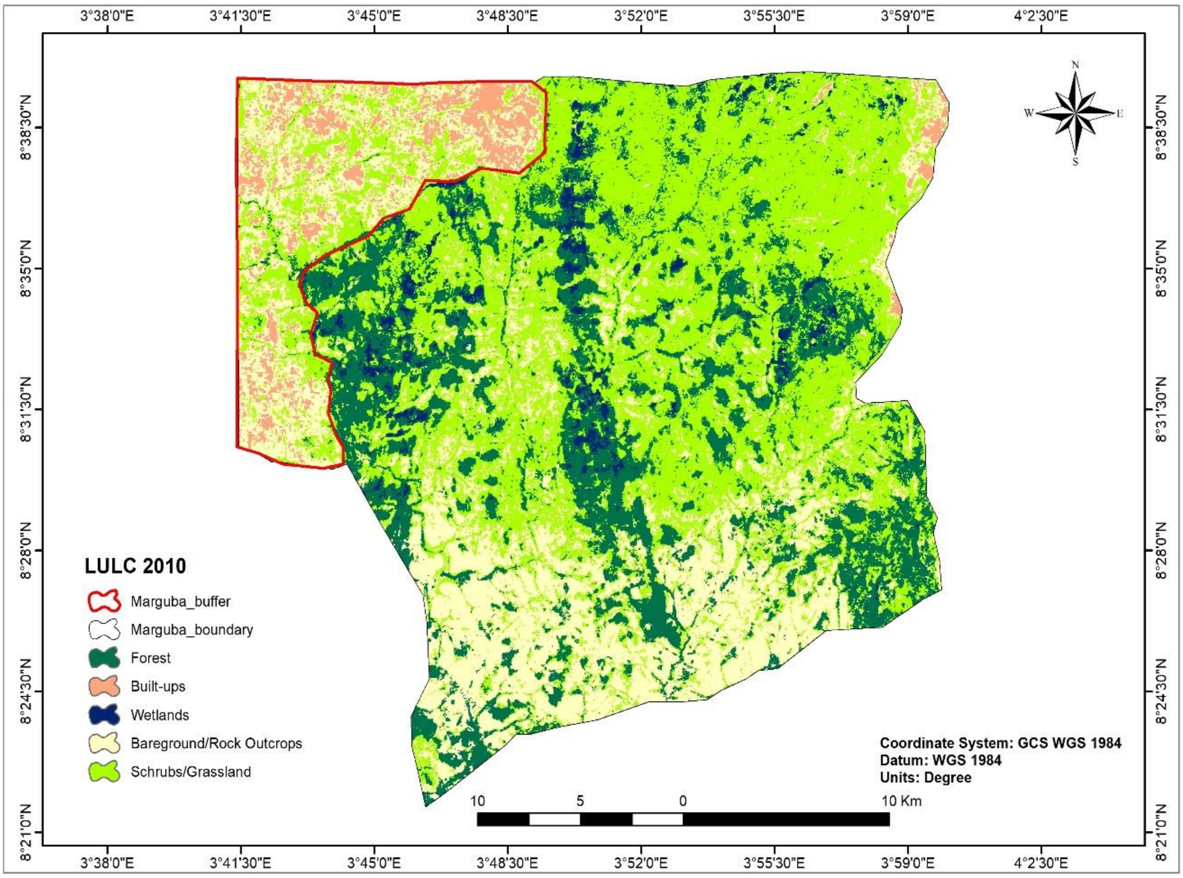

Figure 4.7. Map of Land Use/Land Cover of Buffer and Core zones of the Marguba range of Old Oyo National Park in 2010

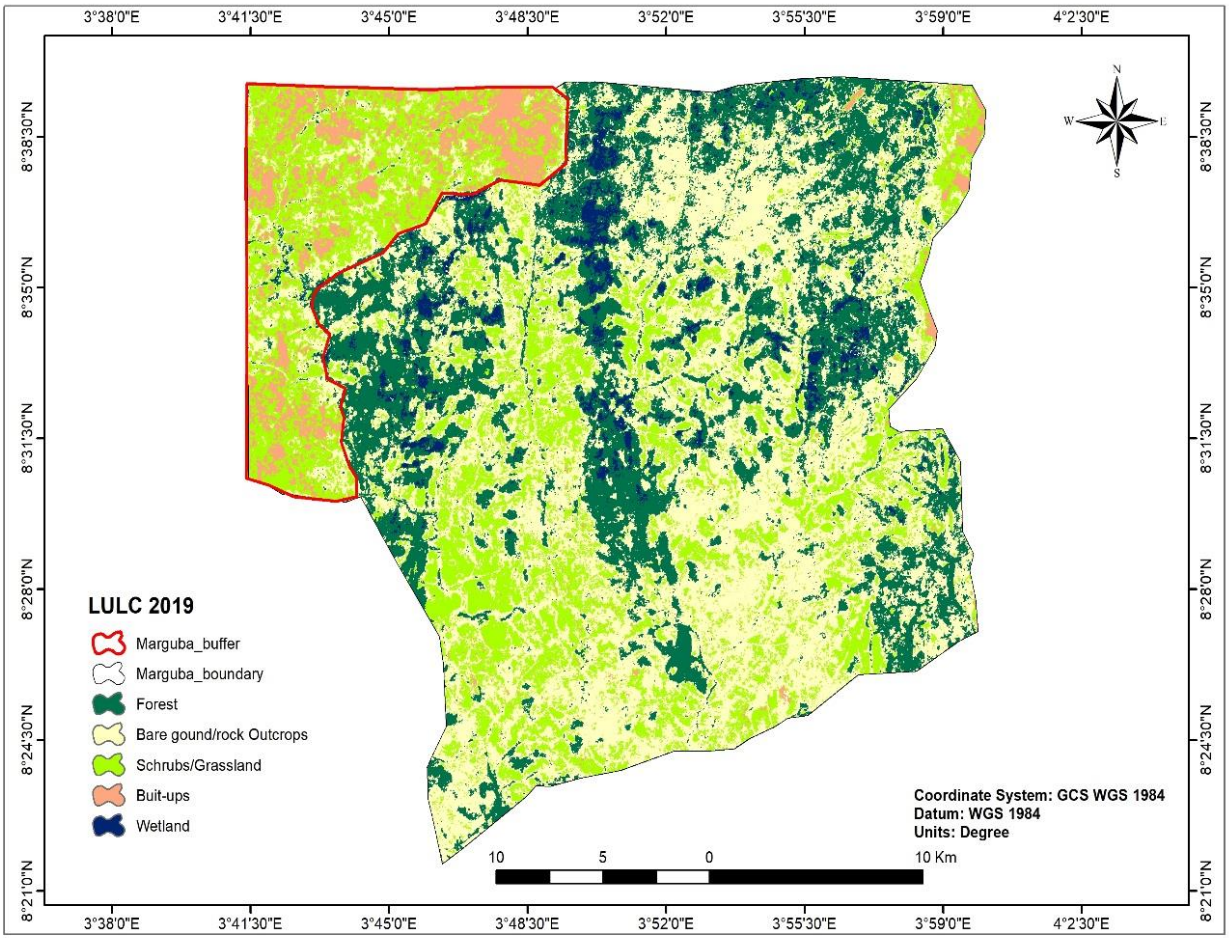

Figure 4.8. Map of Land Use/Land Cover of Buffer and Core zones of the Marguba range of Old Oyo National Park in 2019

Table 4.8. Rate of change of the Land use/ Land cover change classes between 1990 and 2019 in Marguba range of Old Oyo National Park

LULC Classes	1990 to 2000		2000 to 2010		2010 to 2019		1990 to 2019	
	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%
Forest	-264.00	-0.32	+393.00	+0.49	+251.11	+0.26	+122.41	+0.14
Bare surface /Rocky outcrop	+861.00	+1.02	-790.00	-0.91	+1671.11	+1.93	+543.10	+0.64
Wetland	+115.00	+0.14	-284.00	-0.34	+213.33	+0.25	+7.93	+0.01
Shrubs/Grassland	-798.00	-0.95	+541.00	+0.70	-2050.00	-2.50	-724.83	-0.90
Built-up	+93.00	+0.11	+43.00	+0.06	+74.44	+0.08	+70.00	+0.08

Note: Values with negative (-) sign means decrease while increase carries the positive sign (+), LULC- Land use/Land cover

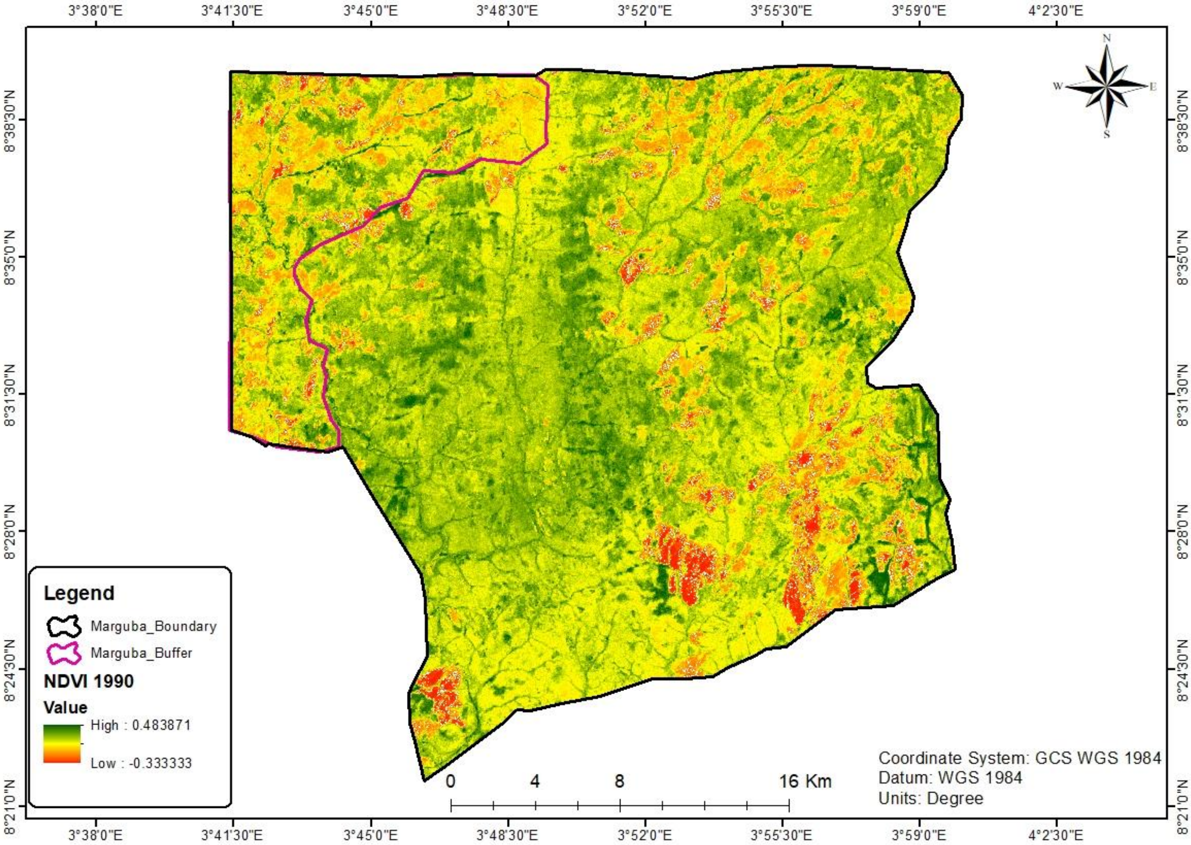

Figure 4.9. **Normalised Difference Vegetation Index of Core and Buffer zones of the Marguba range of Old Oyo National Park in 1990**

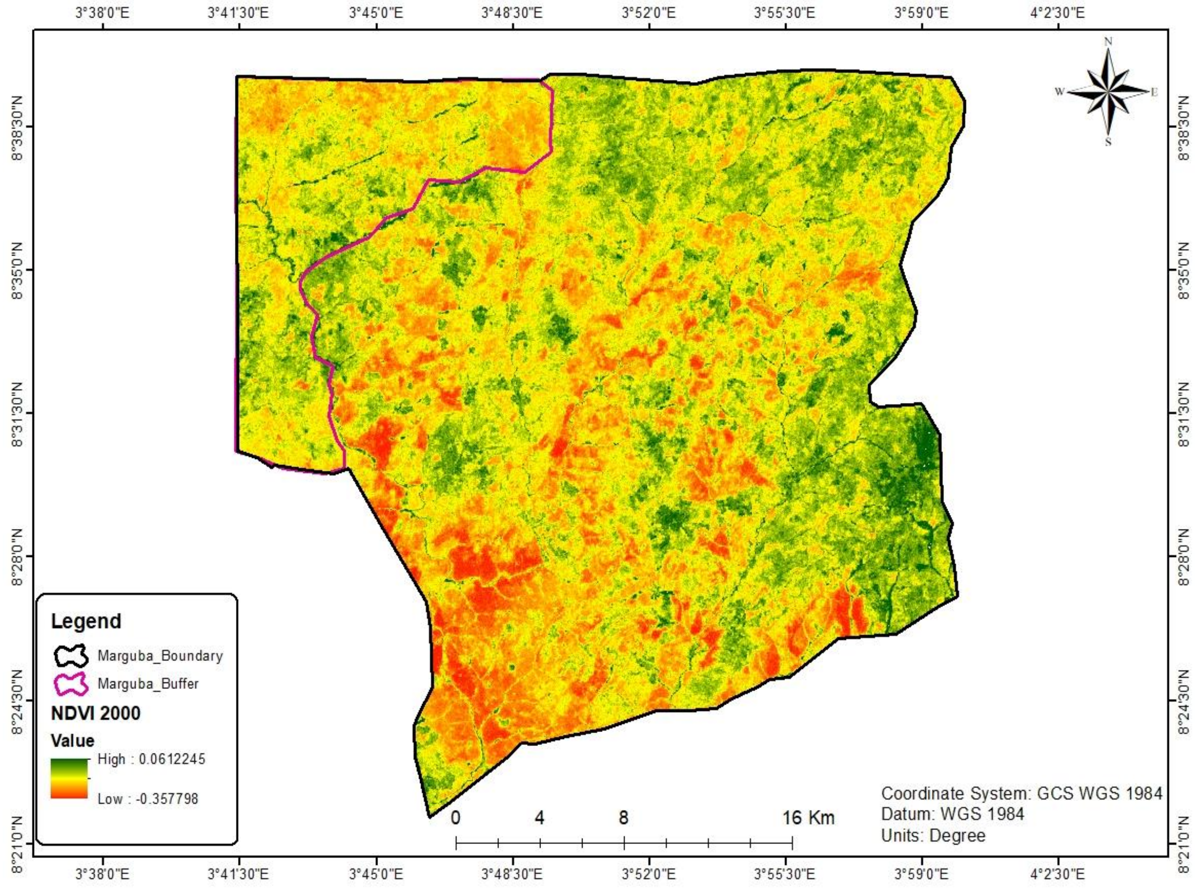

Figure 4.10. Normalised Difference Vegetation Index of Core and Buffer zones of the Marguba range of Old Oyo National Park in 2000

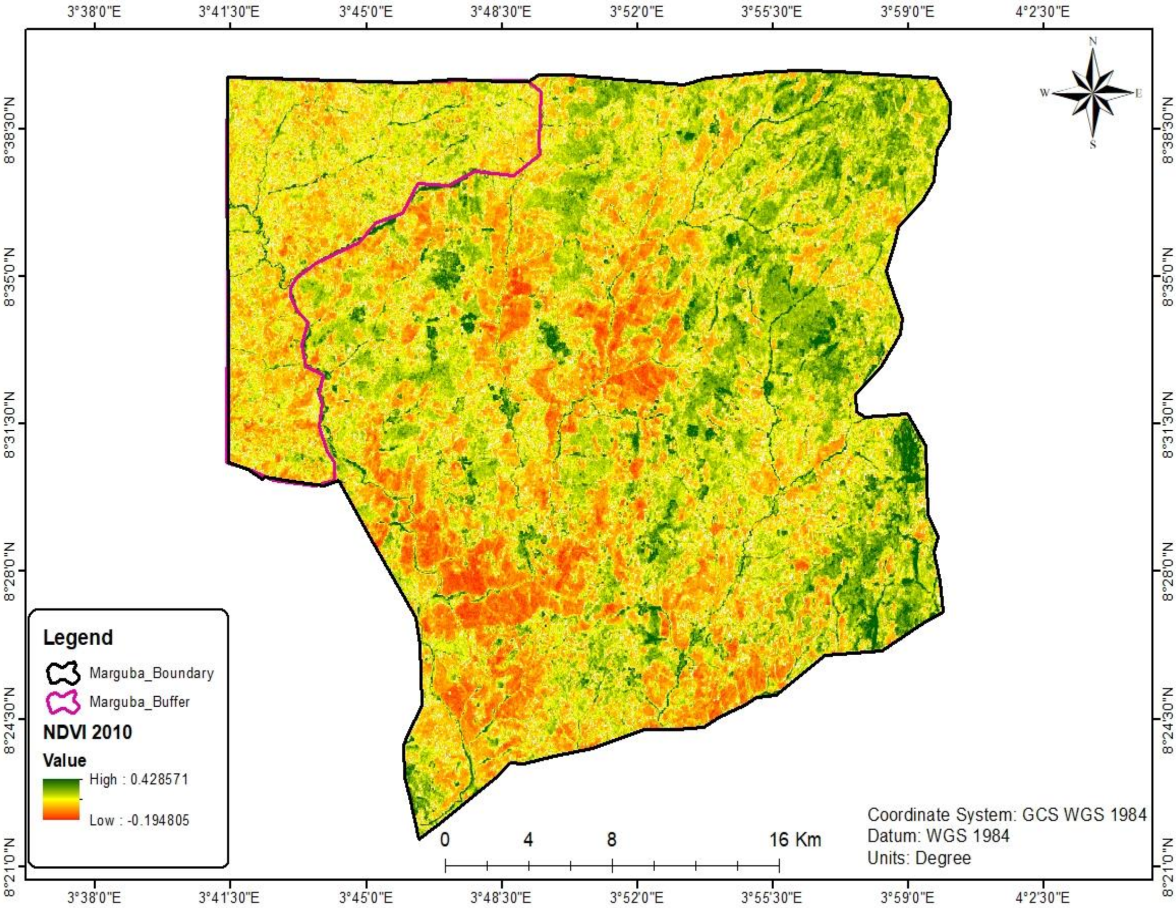

Figure 4.11. Normalised Difference Vegetation Index of Core and Buffer zones of the Marguba range of Old Oyo National Park in 2010

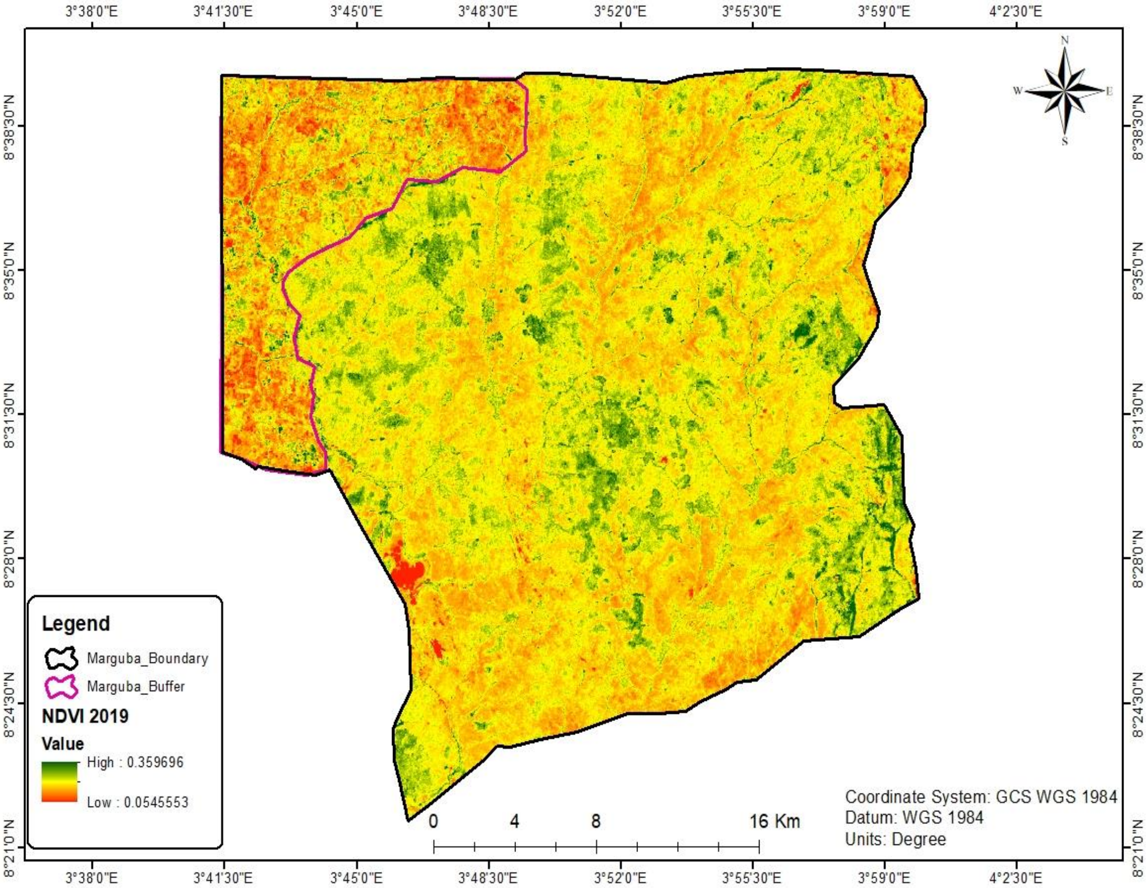

Figure 4.12. Normalised Difference Vegetation Index of Core and Buffer zones of the Marguba range of Old Oyo National Park in 2019

Plate 4.1. **Activities of herdsmen and their herds of cattle in the Marguba range of Old Oyo National Park during field survey in 2017**

Plate 4.2. **Rocky outcrop in the Marguba range of Old Oyo National Park showing burning activities in the park and a baboon (In the orange outlined circle)**

4.4.3.1 Taxonomy and Species composition of the woody species in the Buffer and Core zones of the Marguba Range of Old Oyo National Park

A total of 48 woody species belonging to 22 families were enumerated in the Buffer and Core zones. The survey for diversity of woody plants species revealed that the Core zone had the highest species composition. In the Core zone, forty-one (41) species from 26 families were found (Table 4.10) while 28 plant species in 18 families were recorded in the Buffer zone (Table 4.11).

The study further revealed peculiarity of species to each zone. Buffer zone had Seven species, which were – *Strycnos spinosa*, *Entada africana*, *Acacia sieberiana*, *Sterospermum acuminatissimum*, *Prosopis africana*, *Flueggea virosa*, *Azardirachta indica* while the Core zone had Twenty (20) species that were commonly encountered – *Mitragyna inermis, Psorospermum febrifugum, Isoberlina doka, Ficus thonningii, Albizia lebbeck*, *Bombax constratum, sterculia setigera, Syzygium guineense*, *Afzelia Africana*, *Gmelina arborea*, *Tectona grandis*, *Anthocleista djalonensis*, *Parinari curatellifolia*, *Blighia sapida*, *Combretum collinum*, *Gardenia imperialis, Desmodium velutinum, Grewia mollis*, and *Cussonia barteri*. Twenty-one (21) species of woody plants were common to both zones. These were: *Lophira lanceolata*, *Piliostigma thonningii, Khaya grandifoliola, Ficus exasperata, Daniella oliveri, Azanza garckeana, Annona senegalensis, Vitellaria paradoxa, Bridelia ferruginea, Detarium mycrocarpum, Terminalia macroptera, Burkea Africana, Maytenus seneghalensis, Pseudocedrela kotschyii, Nauclea latifolia, Anogeissus leiocarpus, Ziziphus mucronata, Lannea welwitschii*, *Albizia zygia, Gardenia aqualla, and Pterocarpus erinaceus*. The most common species in the Core zone were *Lophira lanceolata, Anogeissus leiocarpus, Khaya grandifoliola and Piliostigma thonningii* (Table 4.10) while the species commonly encountered at the Buffer zone included *Lophira lanceolata*, *Nauclea Latifolia, Khaya grandifoliola* and *Vitellaria paradoxa* (Table 4.11).

Family fabaceae recorded the highest number of species (13) followed by Malvaceae and Rubiaceae with Four species each. Families Combretaceae and Meliaceae recorded three species each, Lamiaceae, Loganiaceae, Moraceae, and Phyllanthaceae recorded two species each while other families such as Anarcadiaceae, Annonaceae, Araliaceae, Bignoniaceae, Bixaceae, Celastraceae, Chrysobalanaceae, Hypericaceae, Myrtaceae, Ochnaceae, Rhamnaceae, Sapindaceae and Sapotaceae recorded one species each (Table 4.10 and Table 4.11).

Table 4.9. Herbaceous species encountered in the first- and second-year enumeration of the Buffer and Core zones of Old Oyo National Park, in 2017 and 2019, respectively

S/N	Family	Herbaceous species	First year				Second year			
			Buffer		Core		Buffer		Core	
			Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
1	Acanthaceae (4)	*Asystasia gangetica* (Linn.) T. Anders.	-	-	+	-	-	-	+	+
2		*Hypoestes cancellata* Nees	-	-	+	-	+	-	+	-
3		*Monechma ciliatum* (Jacq.) Milne-Redhead	+	-	+	-	-	-	+	-
4		*Nelsonia scandens* (Lam.) Spreng.	-	-	-	-	+	-	+	-
5	Amaranthaceae (4)	*Alternanthera sessillis* Desv.	-	-	+	-	-	-	-	-
6		*Celosia argentia Linn.*	-	-	-	-	-	-	-	+
7		*Cyathula prostrata* (L.) Blume	+	-	+	-	-	-	+	-
8		*Gomphrena celosioides* Mart.	+	-	+	-	+	-	+	-
9	Apiaceae (1)	*Centella asiastica* (L.) Urban	-	-	+	-	+	-	+	-
10	Asparagaceae (1)	*Agave tequilana* F. A. C. Weber	+	-	+	-	-	-	-	-
11	Asteraceae (10)	*Ageratum conyzoides* Linn.	+	-	-	-	-	-	-	-
12		*Aspilia bussei* O. Hoffm. & Muschl.	+	+	+	+	+	+	+	+
13		*Bidens pilosa* Linn.	-	-	+	-	-	-	+	-
14		*Chromolaena odorata* (L.) R.M. King & Robinson	+	+	+	+	+	+	+	+
15		*Spilanthes costata* Benth.	-	-	+	-	-	-	-	-
16		*Synedrella nodiflora* Gaertn.	-	-	+	-	-	-	-	-
17		*Tithonia diversifolia* (Hemsl.) A. Gray	-	-	-	-	+	-	+	-
18		*Tridax procumbens* Linn.	+	-	+	-	+	-	+	-
19		*Vernonia galamensis* (Cass.)	-	-	+	-	-	-	-	-
20		*Vernonia perrottetti* Sch. Bip.	+	-	+	-	-	-	-	-

S/N	Family	Herbaceous Species	First Year				Second year			
			Buffer		Core		Buffer		Core	
			Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
21	Athyriaceae (1)	*Diplazium sammatii* (Kuhn) C. Chr.	+	-	+	-	-	-	-	-
22	Azollaceae (1)	*Azolla pinnata* R. Br.var	+	-	+	-	-	-	+	-
23	Balanophoraceae (1)	*Thonningia sanguinea* Vahl	+	-	-	-	+	-	-	-
24	Commelinaceae (2)	*Commelina benghalensis* L.	+	-	+	-	-	-	-	-
25		*Commelina erecta* L.	-	-	-	-	+	-	+	-
26	Connaraceae (1)	*Brysocarpus coccineus* Schum. & Thonn.	+	-	-	-	-	-	-	-
27	Convolvulaceae (1)	*Ipomoea aquatica* Forsk.	-	-	+	-	-	-	-	-
28	Cyperaceae (4)	*Cyperus iria* Linn	+	-	+	-	+	-	+	-
29		*Cyperus rotundus* L.	-	-	-	-	-	+	-	-
30		*Kyllinga pumila* Michx.	+	-	+	-	+	-	+	-
31		*Scleria naumanniana* Boeck.	+	-	+	-	-	-	-	-
32	Euphorbiaceae (6)	*Croton hirtus* L'Herit	+	-	+	-	+	-	+	-
33		*Euphorbia hirta* Linn.	+	-	+	-	+	-	+	-
34		*Euphorbia hyssopifolia* Linn.	+	-	+	-	+	-	+	-
35		*Manihot esculentus* Crantz	+	-	-	-	+	-	-	-
36		*Phyllanthus niruri* (Schum. & Thonn.) Learndri	-	-	+	-	+	-	-	-
37		*Phyllanthus pentandrus* Schum. & Thonn.	+	-	+	-	-	-	+	-
38	Fabaceae (17)	*Aeschynomene indica* Linn.	+	-	+	-	-	-	-	-
39		*Calopogonium mucunoides* Desv.	+	-	-	-	+	-	-	-
40		*Centrosema pubescens* Benth.	-	-	-	-	+	-	+	-
41		*Chamaecrista mimosoides* (L.) Greene	+	-	+	-	+	+	+	+
42		*Crotalaria macrocalyx* Benth.	+	-	-	-	-	-	-	-

S/N		Herbaceous Species	First Year				Second Year			
			Buffer		Core		Buffer		Core	
			Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
43		*Desmodium scorpiurus* (Sw.) Desv.	+	-	+	-	+	-	+	-
44		*Desmodium velutinum* (Willd.) DC.	-	-	+	-	-	-	-	-
45		*Eriosema psoraleoides* (Lam.) G. Don	+	-	-	-	-	-	-	-
46		*Indigofera hirsuta* Linn.	-	-	-	-	+	-	-	-
47		*Mucuna sloanei* Fawcett & Rendle	+	-	+	-	-	-	-	-
48		*Pueraria phaseoloides* (Roxb.) Benth.	+	-	-	-	-	-	-	-
49		*Senna obtusifolia* (L.) Irwin & Barneby	+	-	-	-	-	-	-	-
50		*Stylosanthes guianensis* (Aublet.) Sw.	+	-	-	-	-	-	-	-
51		*Stylosanthes hamata* (L.) Taub.	-	-	+	-	-	-	-	-
52		*Tephrosia bracteolata* Guill. & Perr.	+	-	+	+	+	+	+	+
53		*Tephrosia linearis* (Willd.) Pers.	+	-	+	-	-	-	-	-
54		*Tephrosia pedicellata* Bak.	+	-	+	-	+	-	+	-
55	Lamiaceae (2)	*Hyptis scipigera* Lam.	+	-	+	-	-	-	+	-
56		*Solenostemon monostachyus* (P. Beauv.) Brig.	+	-	+	-	+	-	+	-
57	Loganiaceae (1)	*Spigellia anthelmia* Linn.	+	-	+	-	+	+	+	-
58	Lythraceae (1)	*Ammannia baccifera* L.	-	-	+	-	-	-	-	-
59	Malvaceae (3)	*Hibiscus asper* Hook. f.	+	-	+	-	+	-	+	-
60		*Sida acuta* Burn. f.	-	-	+	-	-	-	-	-
61		*Sida rhomboidae* L.	+	-	-	-	-	-	-	-
62	Onagraceae (1)	*Ludwigia octavalvis* (Jacq.) P. Raven	-	-	+	-	-	-	-	-
63	Oxalidaceae (1)	*Biophytum petersianum* Klotzsch.	+	-	-	-	-	-	-	-

S/N	Family	Herbaceous Species	First Year				Second Year			
			Buffer		Core		Buffer		Core	
			Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
64	Pedaliaceae (1)	*Sesamum indicum* Linn.	-	-	+	-	-	-	+	-
65	Poaceae (17)	*Acroceras zizanioides* Dandy	+	-	+	-	+	-	+	-
66		*Andropogon tectorum* Schum. & Thonn.	+	+	+	+	+	-	+	-
67		*Axonopus compressus* (Sw.) P. Beauv.	-	-	-	-	+	-	-	-
68		*Brachiaria deflexa* (Schumach.) C.E. Hubbard ex Robyns	+	-	+	-	+	-	+	-
69		*Cymbopogon giganteus* Chiov.	+	-	+	-	-	-	+	-
70		*Echinochloa pyramidalis* Hitchc. & Chase	-	-	-	-	-	-	-	-
71		*Hyparrhenia involucrata* Stapf	+	+	+	+	+	+	+	+
72		*Hyparrhenia rufa* (Nees) Stapf.	-	-	+	-	-	+	+	-
73		*Imperata cylindrica* Linn.	+	+	+	-	+	+	+	+
74		*Leptochloa filiformis* (Lam.) P. Beauv.	+	-	+	-	-	-	-	-
75		*Oplismenus burmannii* (Retz.) P. Beauv.	+	-	+	-	-	-	-	-
76		*Panicum brevifolium* Linn.	-	-	+	-	-	-	-	-
77		*Panicum repens* Linn	-	-	+	-	+	-	+	-
78		*Pennisetum polystachion* (Linn.) Schult.	+	-	+	-	-	-	-	-
79		*Rottboellia cochinchinensis* (Lour.) Clayton	+	+	+	+	+	-	+	-
80		*Setaria megaphylla* (Steud.) Dur. & Schinz	-	-	+	-	+	-	+	-
81	Rubiaceae (3)	*Oldenlandia corymbosa* Linn.	+	-	+	-	+	-	+	-
82		*Spermacoce octodon* (Hepper) Lebrun. & Stork	+	-	+	-	+	-	+	-
83		*Spermacoce ocymoides* Burm. f.	-	-	+	-	-	+	-	-
84	Smilacaceae (1)	*Smilax anceps* Willd.	-	-	+	-	-	-	-	-

S/N	Family	Herbaceous Species	First Year				Second Year			
			Buffer		Core		Buffer		Core	
			Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
85	Sphenocleaceae (1)	*Sphenoclea zeylanica* Gaertn.	+	-	-	-	-	-	-	-
86	Tiliaceae (2)	*Corchorus tridens* Linn.	-	-	-	-	-	-	+	-
87		*Triumpheta rhomboidea* Jacq	+	-	+	+	+	-	+	-
88	Typhaceae (1)	*Typha australis*Schum. & Thonn.	+	-	-	-	-	-	-	-
89	Urticaceae (1)	*Laportea aestuans* (Linn.) Chew.	-	-	-	-	+	-	-	-
90	Verbaceae (1)	*Stachytarpheta cayennensis* (L. C. Rich) Schau.	+	-	+	-	-	-	+	-
91	Vitaceae (1)	*Cissus populnea* Guill. & Perr.	-	-	-	-	-	-	+	-
92	Zingiberaceae (2)	*Aframomum sceptrum* (Oliv. & Hanb.) K Schum.	+	-	+	-	+	-	+	-
93		*Zingiber officinale* Rosc.	-	-	+	-	-	-	-	-
	Total		57	6	68	9	42	11	48	10

+= Presence; - = Absence

Table 4.10. Woody species encountered in the Core zone of the Marguba Range of Old Oyo National Park, Nigeria

S/N	Family	Woody species	Plant form
1	Anacardiaceae (1)	*Lannea welwitschii* (Hiern) Engl.	Tree
2	Annonaceae (1)	*Annona senegalensis* Pers.	Tree
3	Araliaceae (1)	*Cussonia barteri* Seem.	Tree
4	Bixaceae (1)	*Cochlospermum planchonii* Hook. f.	Shrub
5	Celastraceae (1)	*Maytenus seneghalensis* (Lam.) Exell	Tree
6	Chrysobalanaceae (1)	*Parinari curatellifolia* Planch. ex Benth.	Tree
7	Combretaceae (3)	*Anogeissus leiocarpus* (DC.) Guill. & Perr.	Tree
8		*Combretum collinum* Loefl.	Tree
9		*Terminalia macroptera* Guill. & Perr.	Tree
10	Fabaceae (10)	*Afzelia africana* Sm.	Tree
11		*Albizia lebbeck* (Linn.) Benth.	Tree
12		*Albizia zygia* (DC.) J. F.Macbr.	Tree
13		*Burkea Africana* Hook.	Tree
14		*Daniella oliveri* (Rolfe) Hutch. & Dalz.	Tree
15		*Desmodium velutinum* (Willd.) D.C.	Shrub
16		*Detarium microcarpum* Harms	Tree
17		*Isoberlinia doka* Craib & Stapf	Tree
18		*Piliostigma thonningii* (Schum.) Milne-Redh.	Tree
19		*Pterocarpus erinaceus* Poir.	Tree
20	Hypericaceae (1)	*Psorospermum febrifugum* Spach	Tree
21	Lamiaceae (2)	*Gmelina arborea* Roxb. ex Sm.	Tree
22		*Tectona grandis* L. f.	Tree
23	Loganiaceae (1)	*Anthocleista djalonensis* A. Chev.	Tree
24	Malvaceae (4)	*Azanza garckeana* (F. Hoffm.) Exell & Hillc.	Tree
25		*Bombax constratum Pellegr. & Vuillet*	Tree
26		*Grewia mollis* Juss	Tree
27		*Sterculia setigera* Del.	Tree
28	Meliaceae (2)	*Khaya grandifoliola* C. DC.	Tree
29		*Pseudocedrela kotschyii* (bark)	Tree
30	Moraceae (2)	*Ficus exasperata* Vahl	Shrub
31		*Ficus thonningii* Blume	Tree
32	Myrtaceae (1)	*Syzygium guineense* (Willd.) DC.	Tree
33	Ochnaceae (1)	*Lophira lanceolata van Tiegh.ex Keay*	Tree
34	Phyllanthaceae (1)	*Bridelia ferruginea* Benth.	Tree
35	Rhamnaceae (1)	*Ziziphus mucronata* Willd.	Tree
36	Rubiaceae (4)	*Gardenia aqualla* Stapf & Hutch.	Tree
37		*Gardenia imperialis* K. Schum.	Tree
38		*Mitragyna inermis* (Willd.) O Ktze.	Tree
39		*Nauclea latifolia* Smith	Tree
40	Sapindaceae (1)	*Blighia sapida* K.D. Koenig	Tree
41	Sapotaceae (1)	*Vitellaria paradoxa* C. F. Gaertn.	Tree

Table 4.11. Woody species encountered in the Buffer zone of the Marguba Range of Old Oyo National Park, Nigeria

S/N	Family	Woody species	Plant form
1	Anacardiaceae (1)	*Lannea welwitschii* (Hiern) Engl.	Tree
2	Annonaceae (1)	*Annona senegalensis* Pers.	Tree
3	Bignoniaceae (1)	*Stereospermum acuminatissimum* K. Schum.	Tree
4	Celastraceae (1)	*Maytenus seneghalensis* (Lam.) Exell	Tree
5	Combretaceae (2)	*Anogeissus leiocarpus* (DC.) Guill. & Perr.	Tree
6		*Terminalia macroptera* Guill. & Perr.	Tree
7	Fabaceae (9)	*Acacia sieberiana* DC.	Tree
8		*Albizia zygia* (DC.) J. F.Macbr.	Tree
9		*Burkea Africana* Hook.	Tree
10		*Daniella oliveri* (Rolfe) Hutch. & Dalz.	Tree
11		*Detarium microcarpum* Harms	Tree
12		*Entada Africana* Guill. & Perr.	Tree
13		*Piliostigma thonningii* (Schum.) Milne-Redh.	Tree
14		*Prosopis africana* (Guill. & Perr.	Tree
15		*Pterocarpus erinaceus* Poir.	Tree
16	Loganiaceae (1)	*Strychnos spinosa* Lam.	Tree
17	Malvaceae (1)	*Azanza garckeana* (F. Hoffm.) Exell & Hillc.	Tree
18	Meliaceae (3)	*Azadirachta indica* A. Juss.	Tree
19		*Khaya grandifoliola* C. DC.	Tree
20		*Pseudocedrela kotschyii* (bark)	Tree
21	Moraceae (1)	*Ficus exasperata* Vahl	Shrub
22	Ochnaceae (1)	*Lophira lanceolata van Tiegh.ex Keay*	Tree
23	Phyllanthaceae (2)	*Bridelia ferruginea* Benth.	Tree
24		*Flueggea virosa* (Roxb. ex. Willd.)	Shrub
25	Rhamnaceae (1)	*Ziziphus mucronata* Willd.	Tree
26	Rubiaceae (2)	*Gardenia aqualla* Stapf & Hutch.	Tree
27		*Nauclea latifolia* Smith	Tree
28	Sapotaceae (1)	*Vitellaria paradoxa* C. F. Gaertn.	Tree

4.4.3.2 Taxonomy and Species composition of the soil seed bank in the Buffer and Core zones of the Marguba Range of Old Oyo National Park

The emerged herbaceous flora of the soil seed bank in the study plots (Buffer and Core) showed there were 46 species in 20 families. In the first and second wet season, Buffer recorded 22 and 15 species from 11 and 12 families, respectively while Core recorded 24 and 11 species from 13 and 8 (eight) families, respectively (Table 4.12). In first and second dry season seedling emergence, Buffer zone recorded 20 and 21 species in 12 and 10 (Ten) families while Core zone recorded 27 and 21 species in 14 and 14 families, respectively.

Among the families enumerated, Asteraceae had the highest number of species (8) followed by family Poaceae (7), Fabaceae (6 species), Amaranthaceae (4 species), Tiliaceae (3 species) while families Commelinaceae, Urticaceae and Euphorbiaceae recorded 2 species each and Families Araceae, Azollaceae, Cucurbitaceae, Cyperaceae, Lamiaceae, Loganiaceae, Nyctaginaceae, Onagraceae, Piperaceae, Rubiaceae, Scrophulariaceae, Talinaceae recorded one species each.

Herbaceous species that were common to the Buffer zone included *Cyatula prostata*, *Tridax procumbens*, *Calopogonium mucunoides*, *Solenostemon monostachyus*, and *Boerhavia diffusa* while eight species were common to the Core zone and they were *Tithonia diversifolia*, *Commelina benghalensis*, *Momordica charantia*, *Euphorbia hyssopifolia*, *Imperata cylindrica*, *Lindernia crustacea*, *Talinum fruticosum*, and *Larportea aestuans* (Table 4.12).

Table 4.12. Species found in the soil seed bank of the Core and Buffer zones of the Marguba Range of Old Oyo National Park in 2017-2019

S/N	Family	Herbaceous species	First year				Second year			
			Buffer		Core		Buffer		Core	
			Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
1	Amaranthaceae (4)	*Amaranthus hybridus* Linn.	+	+	+	+	-	-	-	+
2		*Celosia argentia* Linn.	+	-	-	+	-	-	-	-
3		*Celosia isertii* C.C. Townsend	+	+	-	+	-	-	-	-
4		*Gomphrena celosioides* Mart.	+	-	-	+	+	-	-	-
5	Araceae (1)	*Stylochaeton natalensis* Schott	-	-	-	+	-	+	+	+
6	Asteraceae (8)	*Ageratum conyzoides* Linn.	+	+	+	+	+	-	-	+
7		*Aspilia bussei* O. Hoffm. & Muschl.	+	+	+	+	+	+	+	+
8		*Chromolaena odorata* (L.) R.M. King & Robinson	+	+	+	+	+	+	+	+
9		*Cyatula prostata* (Linn.) Blume	-	+	-	-	-	-	-	-
10		*Spilanthes costata* Benth.	+	+	+	+	+	+	-	-
11		*Synedrella nodiflora* Gaertn.	-	-	-	-	-	+	+	-
12		*Tithonia diversifolia* (Hemsl.) A. Gray	-	-	+	+	-	-	-	-
13		*Tridax procumbens* Linn.	-	-	-	-	-	+	-	-
14	Azollaceae (1)	*Azolla pinnata* R.Br.	-	-	-	-	+	-	+	+
15	Commelinaceae (2)	*Commelina benghalensis* L.	-	-	+	+	-	-	-	-
16		*Commelina erecta* L.	-	+	+	+	-	-	-	-
17	Cucurbitaceae (1)	*Momordica charantia* Linn.	-	-	-	+	-	-	-	-
18	Cyperaceae (1)	*Cyperus rotundus* Linn.	+	+	+	+	+	+	+	+
19	Euphorbiaceae (2)	*Euphorbia hyssopifolia* Linn.	-	-	-	+	-	-	-	+
20		*Phyllanthus niruri* (Schum. & Thonn.) Learndri	+	+	+	-	+	-	-	-
21	Fabaceae (6)	*Aeschynomene indica* Linn.	+	+	+	+	-	-	-	-
22		*Calopogonium mucunoides* Desv.	-	-	-	-	-	+	-	-
23		*Centrosema pubescens* Benth.	-	+	+	-	-	-	-	-
24		*Chamaecrista mimosioides* (L.) Greene	-	-	-	-	-	+	-	+

S/N	Family	Herbaceous Species	First Year Buffer Wet	First Year Buffer Dry	First Year Core Wet	First Year Core Dry	Second Year Buffer Wet	Second Year Buffer Dry	Second Year Core Wet	Second Year Core Dry
25		*Mucuna pruriens* (Linn.) DC.Var.pruriens	-	-	-	-	+	-	+	-
26		*Tephrosia bracteolata* Guill. & Perr.	+	+	+	+	-	+	-	+
27	Lamiaceae (1)	*Solenostemon monostachyus* (P. Beauv.) Brig.	-	+	+	-	-	-	-	-
28	Loganiaceae (1)	*Spigelia anthelmia* Linn.	+	+	+	+	+	+	+	+
29	Nyctaginaceae (1)	*Boerhavia diffusa* L.	+	-	-	-	-	-	-	-
30	Onagraceae (1)	*Ludwigia abyssinica* A. Rich	-	-	-	-	-	+	-	+
31	Piperaceae (1)	*Peperomia pellucida* (L.) H. B. & K.	+	+	+	+	+	+	+	+
32	Poaceae (7)	*Acroceras zizanioides* Dandy	+	-	-	+	-	-	-	-
33		*Andropogon tectorum* Schum. & Thonn.	+	-	-	-	+	-	-	+
34		*Brachiaria deflexa* (Schumach.) C. E. Hubbard ex Robyns	+	+	+	+	+	+	+	+
35		*Hyparrhenia involucrata* Stapf	-	-	-	-	-	+	-	+
36		*Imperata cylindrica* Linn.	-	-	+	-	-	-	-	-
37		*Oplismenus burmannii* (Retz.) P.Beauv.	-	-	-	-	-	+	-	+
38		*Rottboellia cochinchinensis* (Lour.) Clayton	+	+	+	+	+	-	-	+
39	Rubiaceae (1)	*Oldenlandia corymbosa* Linn.	+	+	+	+	+	+	-	+
40	Scrophulariaceae (1)	*Lindernia crustacea* (L.) F. Muell	-	-	-	-	-	-	-	+
41	Talinaceae (1)	*Talinum fruticosum* (L.) Juss.	-	-	+	-	-	-	-	-
42	Tiliaceae (3)	*Corchorus olitorius* L.	+	-	+	+	-	-	-	-
43		*Corchorus tridens* L.	-	-	+	-	+	+	-	-
44		*Triumpheta rhomboidea* Jacq.	-	-	-	+	-	+	-	-
45	Urticaceae (2)	*Laportea aestuans* (Linn.) Chew.	-	-	-	+	-	-	-	+
46		*Pouzolzia guineensis* Benth.	+	+	+	+	+	-	+	-
	Total		22	20	24	27	15	21	11	21

+ = Presence; - = Absence

4.5 Relative importance value (RIV) of species enumerated in the Buffer and Core Zones of the Marguba Range of Old Oyo National Park

4.5.1 Species composition of the First and Second wet season survey of herbaceous species

Chromolaena odorata was the most common species in the buffer zone with relative importance value of 14.90%/ha and closely followed by *Hyparrhenia involucrata* (10.05%/ha) and in the first wet season, while *Imperata cylindrica* (16.60%/ha) had the highest RIV in the second wet season followed by *Chromolaena odorata* (12.55%/ha) (Table 4.13). The species with low relative importance values were *Ageratum conyzoides* (0.105/ha), *Agave tequiliana* (0.20%/ha), and *Hibiscus asper* (0.07%/ha), Aframomum sceptrum (0.11%/ha) in the first and second wet seasons, respectively. *Chromolaena odorata* was the most common specie in the Core zone with relative importance value 17.01%/ha followed closely by *Hyparrhenia involucrata* (7.98%/ha) in the first wet season enumeration while *Chromolaena odorata* (13.45%/ha) and *Aspilia bussei* (11.90%/ha) had the highest relative importance values in the second wet season. The low RIV was recorded for *Bidens pilosa* (0.08%/ha), *Vernonia galamensis* (0.08%/ha), *Cymbopogon giganteus* (0.03%/ha) in the first wet season and *Bidens pilosa* (0.04%/ha) and *Sesamum indicum* (0.03%/ha) in the second wet season (Table 4.13).

4.5.2 Species composition of the Buffer and Core Zones in the first and second dry season survey of herbaceous species

Hyparrhenia involucrata had the highest RIV in the buffer zone (46.69%/ha and 49.60%/ha) followed by *Chromolaena odorata* with 23.49%/ha and 15.36%/ha in the first and second dry season, respectively; with the least belonging to *Aspilia bussei* (1.95%/ha) and *Rottboellia cochinchinensis* (4.24%/ha) in the first dry season and *Tephrosia bracteolata* (1.03%/ha) and *Hyparrhenia rufa* (1.90%/ha) in the second dry season (Table 4.14). *Andropogon tectorum* had the highest RIV in the core zone (30.59%/ha) followed by *Hyparrhenia involucrata* (29.51%); *Hyparrhenia involucrata* (43.92%/ha) and *Chromolaena odorata* (19.61%/ha) in the first and second dry season, respectively while the least RIV was *Hyparrhenia rufa* (0.93%/ha) and *Triumphetta rhomboidea* (1.11%/ha); *Rottboellia cochinchinensis* (0.09%/ha) and *Tephrosia bracteolata* (0.42%/ha) in the first and second dry season, respectively (Table 4.14).

Table 4.13. Floristic composition, Relative Importance Value (RIV) of the herbaceous flora of the Buffer and Core Zone of the Marguba Range of Old Oyo National Park in first and second wet season

S/N	Herbaceous	RIV FWS		RIV SWS	
		Buffer	Core	Buffer	Core
1	*Acroceras zizanioides*	0.42	0.83	0.26	0.20
2	*Aeschynomene indica*	0.51	0.38	-	-
3	*Aframomum sceptrum*	1.01	0.63	0.11	0.69
4	*Agave tequilana*	0.20	0.10	-	-
5	*Ageratum conyzoides*	0.10	-	-	-
6	*Alternanthera sessillis*	-	0.13	-	-
7	*Ammannia baccifera*	-	0.24	-	-
8	*Andropogon tectorum*	5.96	2.37	1.05	4.31
9	*Aspilia bussei*	7.82	8.67	8.55	11.90
10	*Asystasia gangetica*	-	1.03	-	0.39
11	*Axonopus compressus*	0.81	-	0.48	-
12	*Azolla pinnata*	-	0.56	-	0.26
13	*Bidens Pilosa*	-	0.08	-	0.04
14	*Biophytum petersianum*	1.67	-	-	-
15	*Boerhavia diffusa*	-	-	1.35	0.05
16	*Brachiaria deflexa*	1.77	3.70	1.59	2.01
17	*Brysocarpus coccineus*	1.77	-	-	-
18	*Calopogonium mucunoides*	0.59	-	0.23	-
19	*Centella asiastica*	-	1.36	0.16	4.10
20	*Centrosema pubescens*	-	-	0.21	0.17
21	*Chamaecrista mimosoides*	0.61	1.45	1.42	1.56
22	*Chromolaena odorata*	14.90	17.01	12.55	13.45
23	*Cissus populnea*	-	-	-	0.41
24	*Commelina benghalensis*	-	1.93	-	-
25	*Commelina erecta*	-	-	3.60	3.88
26	*Corchorus tridens*	-	-	-	0.52
27	*Crotalaria macrocalyx*	0.52	-	-	-
28	*Croton hirtus*	0.49	0.12	0.38	0.12
29	*Cyatula prostrata*	0.67	1.49	-	1.38
30	*Cymbopogon giganteus*	1.04	0.03	-	0.04
31	*Cyperus iria*	2.82	1.25	3.81	1.46
32	*Desmodium scorpiurus*	0.16	0.11	0.41	0.39
33	*Desmodium velutinum*	-	1.81	-	-
34	*Diplazium samati*	0.20	0.23	-	-
35	*Echinochloa pyramidalis*	-	0.12	-	-
36	*Eriosema psolaroides*	0.22	-	-	-
37	*Euphorbia hirta*	0.94	1.62	3.21	1.43
38	*Euphorbia hyssopifolia*	1.38	0.38	2.70	3.83
39	*Gomphrena celosioides*	0.20	0.31	0.23	0.12
40	*Hibiscus asper*	1.23	1.59	0.07	0.19
41	*Hyparrhenia involucrate*	10.05	7.98	6.07	7.80
42	*Hyparrhenia rufa*	-	0.26	1.56	1.02
43	*Hypoestes cancellate*	-	0.69	0.17	0.45
44	*Hyptis scipigera*	0.36	0.89	-	0.12

S/N	Herbaceous species	RIV FWS		RIV SWS	
		Buffer	Core	Buffer	Core
45	*Imperata cylindrica*	4.16	3.85	16.60	5.73
46	*Indigofera hirsute*	-	-	0.66	-
47	*Ipomoea aquatica*	-	0.08	-	-
48	*Kylinga pumila*	0.53	0.33	0.32	0.47
49	*Larportea aestuans*	-	-	0.86	-
50	*Leptochloa filiformis*	0.31	0.24	-	-
51	*Ludwigia octavalvis*	-	0.64	-	-
52	*Manihot esculentus*	0.14	-	2.69	-
53	*Monechma ciliatum*	2.50	2.44	-	0.54
54	*Mucuna sloanei*	0.75	0.10	-	-
55	*Nelsonia canescens*	-	-	0.12	0.15
56	*Oldenlandia corymbosa*	0.83	0.25	1.38	1.25
57	*Oplismenus burmannii*	0.90	1.67	-	-
58	*Panicum brevifolium*	-	1.01	-	0.61
59	*Panicum repens*	-	2.06	-	-
60	*Pennisetum polystachion*	0.26	0.71	-	-
61	*Phyllanthus niruri*	-	0.59	-	-
62	*Phyllanthus pentandrus*	1.84	0.52	1.13	1.29
63	*Pueraria phaseoloides*	0.70	-	-	-
64	*Rottboellia cochinchinensis*	5.34	6.20	5.19	6.58
65	*Scleria naumannania*	0.29	0.17	-	-
66	*Senna obtusifolia*	0.38	-	-	-
67	*Sesamum indicum*	-	0.10	-	0.03
68	*Setaria megaphylla*	-	0.43	0.39	0.70
69	*Sida acuta*	-	0.22	-	-
70	*Sida rhomboidae*	0.57	-	-	-
71	*Smilax anceps*	-	0.03	-	-
72	*Solenostemon monostachyus*	1.47	1.59	0.11	0.09
73	*Spermacoce octodon*	4.91	5.70	1.04	2.69
74	*Spermacoce ocymoides*	-	1.09	-	-
75	*Sphenoclea zeylanica*	0.18	-	-	-
76	*Spigellia anthelma*	1.51	0.15	6.02	8.51
77	*Spilanthes costata*	-	0.48	-	-
78	*Stachytarpheta cayennensis*	1.15	0.23	-	-
79	*Stylosanthes guianensis*	2.56	-	-	-
80	*Stylosanthes hamata*	-	2.04	-	-
81	*Synedrella nudiflora*	-	0.19	-	0.08
82	*Tephrosia bracteolate*	2.52	1.78	3.46	6.10
83	*Tephrosia linearis*	1.37	1.80	-	-
84	*Tephrosia pedicellate*	0.90	1.85	1.07	0.78
85	*Thonningia sanguinea*	2.68	-	1.91	-
86	*Tithonia diversifolia*	-	-	0.67	-
87	*Tridax procumbens*	0.27	0.22	5.11	0.58
88	*Triumpheta rhomboidei*	0.68	0.91	1.10	1.47
89	*Typha australis*	0.64	-	-	-
90	*Vernonia galamensis*	-	0.08	-	-

S/N	Herbaceous Species	RIV FWS		RIV SWS	
		Buffer	**Core**	**Buffer**	**Core**
91	*Vernonia perrotteti*	0.45	0.62	-	-
92	*Zingiber officinalis*	-	0.26	-	-
	Total	57	68	42	48

Footnote: - = Nil; FWS - First wet season; SWS - Second wet season.

Table 4.14. Herbaceous composition, Relative Importance Value (RIV) of the herbaceous species composition of the Buffer and Core zone of the Marguba Range of Old Oyo National Park in both dry seasons

S/N	Herbaceous	FDS		SDS	
		Buffer	Core	Buffer	Core
1	*Andropogon tectorum*	7.60	30.59	-	15.95
2	*Aspilia bussei*	1.95	8.67	3.64	5.66
3	*Asystasia gangetica*	-	-	-	2.35
4	*Celosia argentia*	-	-	-	1.91
5	*Chamaecrista mimosoides*	-	-	4.56	1.40
6	*Chromolaena odorata*	23.49	18.99	15.36	19.61
7	*Cyperus rotundus*	-	-	2.88	-
8	*Hyparrhenia involucrata*	46.69	29.51	49.60	43.92
9	*Hyparrhenia rufa*	-	0.93	1.90	1.55
10	*Imperata cylindrica*	10.98	2.26	12.25	7.15
11	*Rottboellia cochinchinensis*	9.24	1.12	-	0.09
12	*Spermacoce ocymoides*	-	-	6.46	-
13	*Spigellia anthelma*	-	-	2.33	-
14	*Tephrosia bracteolate*	-	6.83	1.03	0.42
15	*Triumpheta rhomboidae*	-	1.11	-	-
	Total	6	9	10	11

Footnote: - = Nil;

FDS – First dry season;

SDS – Second dry season.

4.5.3 Composition of woody species in the Buffer and Core Zones of the Marguba Range of Old Oyo National Park

In the Buffer zone, *Lophira lanceolata* had the highest RIV and IVI (14.67%/ha and 34.60/ha) followed by *Piliostigma thonningii* (6.65%/ha and 19.02/ha) with the least observed in *Albizia zygia* and *Fleuggea virosa* (0.23%/ha and 2.43/ha; 0.23%/ha and 2.43/ha).

In the Core zone, the highest RIV and IVI was recorded for *Lophira lanceolata* (14.09%/ha and 31.93/ha) followed by *Piliostigma thonningii* (9.41%/ha and 23.00/ha), *Anogeissus leiocarpus* (9.13%/ha and 20.43/ha) while the least was recorded for *Tectona grandis* (0.33%/ha and 1.88/ha) and *Anthocleista djalonensis* (0.27%/ha and 4.18/ha) (Table 4.15)

4.5.4 Composition of species in the seed bank of the soil of Buffer and Core Zones in the First and Second wet season survey of herbaceous species

Cyperus rotundus had the highest RIV in the Buffer zone (30.76%/ha) followed by *Aspilia bussei* (16.33%/ha), *Chromolaena odorata* with (15.88%/ha) in the first wet season; with the least value 0.59%/ha representative of *Tephrosia bracteolata, Phyllanthus niruri, Corchorus olitorius, Celosia isertii, Celosia argentia, and Boerhavia diffusa* (Table 4.16). *Chromolaena odorata* had the highest RIV in the Core zone (21.16%/ha) followed by *Spigelia anthelmia* (12.35%/ha) while *Aeschynomene indica, Ageratum conyzoides, Centrosema pubescens, Commelina erecta, Corchorus olitorius, Imperata cylindrica,* and *Oldenlandia corymbosa* recorded the least RIV (0.61%/ha) in the Core zone.

In the second wet season, *Chromolaena odorata* (39.42%/ha and 37.10%/ha) had the highest RIV followed by *Cyperus rotundus* (20.18%/ha and 21.85%/ha), *Aspilia bussei* (10.78%/ha and 16.98%/ha) in the Buffer and Core zones, respectively. Species with the least RIV (0.68%/ha) included *Corchorus tridens, Gomphrena celosioides*, *Phyllanthus niruri* in the Buffer zone and *Synedrella nodiflora* (0.68%/ha) in the Core zone (Table 4.16).

4.5.5 Composition of herbaceous species in the soil seed bank of the soil of Buffer and Core Zones in the First and Second dry seasons

In the first dry season, *Cyperus rotundus* had the highest RIV (33.01%/ha) followed by *Aspilia bussei* (13.28%/ha) in the Buffer zone with *Chromolaena odorata* (20.66%/ha) followed by *Cyperus rotundus* (18.06%/ha) in the Core zone.

Species with the least RIV (1.29%/ha) in the buffer zone were *Centrosema pubescens, Commelina erecta, Cyatula prostata, Phyllanthus niruri, Solenostemon monostachyus, Spilanthes costata* and *Tephrosia bracteolata*; while *Commelina erecta* and *Tithonia diversifolia* (0.40%/ha) had low relative importance value in the Core zone (Table 4.17).

In the second dry season, *Brachiaria deflexa* had the highest RIV (22.47%/ha) followed by *Cyperus rotundus* (16.59%/ha) in the Buffer zone with *Chromolaena odorata* (26.22%/ha) followed by *Brachiaria deflexa* (17.75%/ha) and *Aspilia bussei* (11.67%/ha) in the Core zone. *Tridax procumbens, Tephrosia bracteolata, and Amaranthus hybridus, Larportea aestuans* had the lowest RIV (0.27%/ha) in the Buffer and Core zones, respectively (Table 4.17).

4.6 Community structure for the vegetation in Buffer and Core zones of the Marguba range in Old Oyo National Park

4.6.1 Community structure of Herbaceous and woody species at the Buffer and Core zones of the Marguba range of Old Oyo National Park

The community structure of herbaceous and woody species for the two years' seasonal enumeration is shown on (Table 4.18). The highest Taxa (68) and number of individuals (4639/ha) were recorded in the Core zone during the first wet season for herbaceous species while the least (taxa =6 and individuals = 956/ha) was recorded in the Buffer zone in the first dry season. There was relatively low dominance in the Buffer and Core zones with 0.06 and 0.08 (First wet season); 0.30 and 0.23 (First dry season); 0.09 and 0.08 (Second wet season); 0.30 and 0.34 (Second dry season), respectively. This means no species was dominated the habitat and they were all randomly distributed in the study area.

Species richness was high in the Buffer and Core zones and the highest (0.94 and 0.92) was recorded during the first wet season while the least (0.70 and 0.66) was recorded during the second dry season, respectively. The highest Shannon-Wiener values for herbaceous species were observed in the first (3.30, 3.16) and second wet season (2.83, 2.87) in the Buffer and Core zones, respectively while the relatively low values were observed in the first (1.42, 1.64) and second dry season (1.53, 1.50) in the Buffer and Core zones, respectively. The equitability index was high within the study area and across the seasons enumerated showing a random distribution of species (Table 4.18).

Table 4.15. Woody composition, Relative Importance Value (RIV) and Importance Value Index (IVI) inventoried in the Buffer and Core zone of the Marguba Range of Old Oyo National Park in 2017/2018

S/N	Woody Species	Buffer		Core	
		RIV	IVI	RIV	IVI
1	*Acacia sieberiana*	1.60	6.66	-	-
2	*Afzellia Africana*	-	-	0.44	3.30
3	*Albizia lebbeck*	-	-	1.04	4.26
4	*Albizia zygia*	0.23	2.43	0.55	2.72
5	*Annona senegalensis*	2.75	8.46	1.92	5.66
6	*Anogeissus leiocarpus*	5.27	14.33	9.13	20.43
7	*Anthocleista djalonensis*	-	-	0.27	4.18
8	*Azanza garckeana*	4.81	12.82	1.81	5.20
9	*Azardirachta indica*	0.23	2.43	-	-
10	*Blighia sapida*	-	-	0.88	3.22
11	*Bombax constratum*	-	-	0.71	4.25
12	*Bridelia ferruginea*	2.52	8.66	1.75	5.39
13	*Burkea Africana*	2.06	7.68	4.70	11.71
14	*Cochlospermum planchonii*	-	-	1.41	5.66
15	*Combretum collinum*	-	-	1.80	6.18
16	*Cussonia barteri*	-	-	4.21	10.66
17	*Daniella oliveri*	1.83	7.62	3.68	8.81
18	*Desmodium velutinum*	-	-	2.84	13.97
19	*Detarium macrocarpum*	2.06	7.68	0.71	4.25
20	*Entada Africana*	2.29	9.52	-	-
21	*Ficus exasperate*	3.44	12.80	1.08	5.81
22	*Ficus thoningii*	-	-	1.58	5.76
23	*Flueggea virosa*	0.23	2.43	-	-
24	*Gardenia aqualla*	2.75	9.45	0.71	4.25
25	*Gardenia imperialis*	-	-	2.02	6.60
26	*Gmelina arborea*	-	-	0.38	2.59
27	*Grewia mollis*	-	-	3.00	8.35
28	*Isoberlina doka*	-	-	1.10	3.81
29	*Khaya gandifoliola*	5.04	12.80	7.50	16.95
30	*Lannea welwitschia*	1.83	7.62	0.77	3.36
31	*Lophira lanceolata*	14.67	34.60	14.09	31.93
32	*Maytenus senegalensis*	1.60	5.51	0.82	3.76
33	*Mitragyna inermis*	-	-	0.83	2.87
34	*Nauclea latifolia*	5.73	15.26	4.83	13.22
35	*Parinari curatellifolia*	-	-	0.44	3.30
36	*Piliostigma thonningii*	6.65	19.02	9.41	23.00
37	*Prosopis africana*	1.15	7.23	-	-
38	*Pseudocedrela kotschyi*	1.60	5.97	3.72	9.59
39	*Psorospermum febrifugum*	-	-	0.93	4.58
40	*Pterocarpus erinaceus*	3.67	10.49	1.20	4.43

S/N	Woody Species	Buffer		Core	
		RIV	IVI	RIV	IVI
41	*Stereospermum acuminatissimum*	1.15	5.58	-	-
42	*Sterculia setigera*	-	-	0.60	3.23
43	*Strychnos spinosa*	2.06	7.09	-	-
44	*Syzygium guineense*	-	-	0.50	2.21
45	*Tectona grandis*	-	-	0.33	1.88
46	*Terminalia macroptera*	2.06	7.68	2.78	8.28
47	*Vitellaria paradoxa*	2.98	7.93	2.69	7.19
48	*Ziziphus mucronata*	3.90	12.59	0.88	3.22
	Total	28		41	

Footnote: - = Nil

Table 4.16. Species composition, Relative Importance Value (RIV) of the herbaceous plants in the soil seed bank of the Buffer and Core zones of the Marguba Range of Old Oyo National Park in the First and Second wet season

S/N	Herbaceous	FWS		SWS	
		Buffer	Core	Buffer	Core
1	*Acroceras zizanioides*	1.17	-	-	-
2	*Aeschynomene indica*	1.17	0.61	-	-
3	*Ageratum conyzoides*	9.19	0.61	6.87	-
4	*Amaranthus hybridus*	1.17	2.45	-	-
5	*Andropogon tectorum*	2.78	3.13	-	-
6	*Aspilia bussei*	16.33	3.08	10.78	16.98
7	*Azolla pinnata*	-	-	1.01	2.56
8	*Boerhavia diffusa*	0.59	-	-	-
9	*Brachiaria deflexa*	5.57	8.18	4.79	2.74
10	*Celosia argentia*	0.59	-	-	-
11	*Celosia isertii*	0.59	-	-	-
12	*Centrosema pubescens*	-	0.61	-	-
13	*Chromolaena odorata*	15.88	21.16	39.42	37.10
14	*Commelina benghalensis*	-	1.84	-	-
15	*Commelina erecta*	-	0.61	-	-
16	*Corchorus olitorius*	0.59	0.61	-	-
17	*Corchorus tridens*	-	1.23	0.68	-
18	*Cyperus rotundus*	30.76	10.09	20.18	21.85
19	*Gomphrena celosioides*	0.59	-	0.68	-
20	*Imperata cylindrica*	-	0.61	-	-
21	*Mucuna pruriens*	-	-	0.85	3.62
22	*Oldenlandia corymbosa*	3.81	0.61	2.38	
23	*Peperomia pellucida*	1.46	5.94	0.85	3.62
24	*Phyllanthus niruri*	0.59	2.68	0.68	
25	*Pouzolzia guineensis*	2.63	2.89	4.08	7.24
26	*Rottboellia cochinchinensis*	1.17	9.60	-	-
27	*Spigelia anthelmia*	1.91	12.35	1.53	2.25
28	*Spilanthes costata*	0.88	2.45	5.20	-
29	*Stylochiton natalensis*	-	-	-	1.37
30	*Synedrella nodiflora*	-	-	-	0.68
31	*Talinum fruticosum*	-	2.87	-	-
32	*Tephrosia bracteolate*	0.59	2.45	-	-
33	*Tithonia diversifolia*	-	3.29	-	-
	Total	22	24	15	11

Table 4.17. Species composition, Relative Importance Value (RIV) of the herbaceous plants in the soil seed bank of the Buffer and Core zones of the Marguba Range of Old Oyo National Park in the First and Second dry season

S/N	Herbaceous	FDS		SDS	
		Buffer	Core	Buffer	Core
1	*Aeschynomene indica*	3.87	0.80	-	-
2	*Ageratum conyzoides*	2.58	0.93	-	1.35
3	*Amaranthus hybridus*	4.40	3.20	-	0.27
4	*Andropogon tectorum*	-	0.40	1.48	3.49
5	*Aspilia bussei*	13.28	6.32	3.89	11.67
6	*Azolla pinnata*	-	-	-	1.08
7	*Brachiaria deflexa*	5.16	7.86	22.47	17.75
8	*Calopogonium zizanioides*	-	-	0.37	-
9	*Celosia argentia*	-	0.40	-	-
10	*Celosia isertii*	2.58	0.40	-	-
11	*Centrosema pubescens*	1.29	-	-	-
12	*Chamaecrista mimosioides*	-	-	1.33	0.63
13	*Chromolaena odorata*	9.03	20.66	8.87	26.22
14	*Commelina benghalensis*	-	3.49	-	-
15	*Commelina erecta*	1.29	0.40	-	-
16	*Corchorus olitorius*	-	2.27	-	-
17	*Corchorus tridens*	-	-	0.53	-
18	*Cyatula prostata*	1.29	-	-	-
19	*Cyperus rotundus*	33.01	18.06	16.59	7.71
20	*Euphorbia hyssopifolia*	-	0.80	-	1.08
21	*Gomphrena celosioides*	-	0.80	-	-
22	*Hyparrhenia involucrata*	-	-	11.20	3.29
23	*Laportea aestuans*	-	0.80	-	0.27
24	*Lindernia sp.*	-	-	-	0.71
25	*Ludwigia abyssinica*	-	-	4.55	1.62
26	*Momordica charantia*	-	1.60	-	-
27	*Oldenlandia corymbosa*	2.58	6.80	2.44	2.75
28	Oplismenus burmannii	-	-	0.53	1.62
29	*Peperomia pellucida*	3.64	7.35	3.63	2.06
30	*Phyllanthus niruri*	1.29	-	-	-
31	*Pouzolzia guineensis*	1.82	0.54	-	-
32	*Rottboellia cochinchinensis*	3.87	5.33	7.21	8.33
33	*Solenostemon monostachyus*	1.29	-	-	-
34	*Spigelia anthelmia*	5.16	2.53	6.19	6.73
35	*Spilanthes costata*	1.29	2.68	2.69	-
36	*Stylochiton natalensis*	-	1.47	0.53	0.81
37	*Synedrella nodiflora*	-	-	3.78	-
38	*Tephrosia bracteolate*	1.29	2.93	0.27	0.54
39	*Tithonia diversifolia*	-	0.40	-	-
40	*Tridax procumbens*	-	-	0.27	-
41	*Triumpheta rhomboidei*	-	0.80	1.17	-
	Total	20	27	21	21

Footnote: - = Nil

For woody species, the highest taxa and individual were recorded in the Core zone (41 and 329/ha) and lowest Buffer zone (28 and 261/ha). Low dominance was recorded with 0.06 and 0.07 with high species richness (0.94 and 0.93) in the Buffer and Core zones, respectively. Shannon-Wiener index was high for woody species in the Buffer (3.02) and Core zone (3.13), woody species were evenly distributed with high equitability index values (0.91 and 0.84) in the Buffer and Core zones, respectively (Table 4.19).

4.6.2 Community structure of Herbaceous species in the soil seed bank of the Buffer and Core zones of the Marguba range of Old Oyo National Park

The result of the diversity indices of the soil seed bank in both seasons is shown on (Table 4.20). The highest taxa (27) and lowest (11) were recorded in the Core zone in the first dry and second wet season, respectively. Highest individual (676) and lowest (65) was recorded in the Buffer zone during the second dry and first dry season, respectively. Low dominance index was recorded for both location across the seasons, the Simpson index was relatively high which means no species dominated the soil seed bank with 0.79 and 0.89 (first wet); 0.82 and 0.87 (first dry); 0.73 and 0.75 (second wet); 0.87 and 0.84 (second dry) seasons in the Buffer and Core zones, respectively.

In the Core zone during the first wet season, the Shannon-Wiener index was 2.57 which was the highest and the lowest (1.65) was recorded in the second wet season. Species were not evenly distributed in the study area with relatively low evenness values but with high equitability values with 0.64 and 0.81 (first wet); 0.76 and 0.75 (first dry); 0.65 and 0.69 (second wet); 0.76 and 0.72 (second dry) seasons in the Buffer and Core zones, respectively (Table 4.20).

4.7 Similarity indices of vegetation types across seasons

4.7.1 Jaccard’s similarity indices of standing vegetation across seasons in the Buffer and Core zones of the Marguba Range of Old Oyo National Park, Nigeria

The Jaccard similarity index shows the extent of similarity among species enumerated in the Buffer and Core zones across seasons. Table 4.21 showed the level of variation between the standing vegetation species enumerated in the Buffer and Core zones across seasons.

Table 4.18. Community structure of the herbaceous species in the Buffer and Core Zones of the Marguba Range of Old Oyo National Park, Nigeria

Community structure	FWS		FDS		SWS		SDS	
	Buffer	Core	Buffer	Core	Buffer	Core	Buffer	Core
Taxa_S	57	68	6	9	42	48	11	10
Individuals	3699	4639	956	1520	2914	3854	1349	1003
Dominance_D	0.06	0.08	0.30	0.23	0.09	0.08	0.30	0.34
Simpson_1-D	0.94	0.92	0.70	0.77	0.91	0.92	0.70	0.66
Shannon_H	3.30	3.16	1.42	1.64	2.83	2.87	1.53	1.50
Evenness_e^H/S	0.43	0.35	0.69	0.57	0.40	0.37	0.42	0.45
Equitability_J	0.80	0.75	0.79	0.75	0.76	0.74	0.64	0.65

FWS = First wet season; FDS = First dry season; SWS = Second wet season; SDS = Second dry season

Table 4.19. Community structure of the woody species in the Buffer and Core Zones of the Marguba Range of Old Oyo National Park, Nigeria

Community structure	Woody	
	Buffer	Core
Taxa_S	28	41
Individuals	261	329
Dominance_D	0.06	0.07
Simpson_1-D	0.94	0.93
Shannon_H	3.02	3.13
Evenness_e^H/S	0.74	0.56
Equitability_J	0.91	0.84

Table 4.20. Community structure of the soil seed bank species of the Buffer and Core Zones of the Marguba Range of Old Oyo National Park, Nigeria

Community structure	FWS		FDS		SWS		SDS	
	Buffer	Core	Buffer	Core	Buffer	Core	Buffer	Core
Taxa_S	22	24	20	27	15	11	21	21
Individuals	240	83	65	127	212	88	676	203
Dominance_D	0.21	0.11	0.18	0.13	0.27	0.25	0.13	0.16
Simpson_1-D	0.79	0.89	0.82	0.87	0.73	0.75	0.87	0.84
Shannon_H	1.97	2.57	2.28	2.49	1.75	1.65	2.31	2.19
Evenness_e^H/S	0.33	0.54	0.49	0.44	0.38	0.47	0.48	0.43
Equitability_J	0.64	0.81	0.76	0.75	0.65	0.69	0.76	0.72

Footnote: FWS = First wet season; FDS = First dry season; SWS = Second wet season; SDS = Second dry season

The highest similarity (72.7%) was observed between species encountered in the Core zone in first and second dry seasons (CFDS (Core First Dry Season) and CSDS (Core Second Dry Season)) followed by 66.7% for species in the Buffer and Core zones in the first dry season (BFDS (Buffer First Dry Season) and CFDS (Core First Dry Season)) and 63.6% in the species in Buffer and Core zone second wet season (BSWS and CSWS) while the least similarity existed between Buffer first dry and Core first wet (BFDS and CFWS) with 8.8% followed by Buffer first wet and dry season (BFWS and BFDS) with 10.7% (Table 4.21).

There was 44% similarity between the woody species enumerated in the Buffer and Core zones of the study area (Table 4.21).

4.7.2 Jaccard's similarity indices of the plant species in the soil seed bank across seasons in the Buffer and Core zones of the Marguba Range of Old Oyo National Park, Nigeria

The highest similarities (63.3%) and (63%) were observed among species in the Buffer first wet season and Core first dry season (BFWS and CFDS) and species enumerated in the Buffer first dry and Core first wet season (BFDS and CFWS), respectively. The least similarities (25% and 26.6%) were observed in the Core first and second wet seasons (CFWS and CSWS) and Core first dry and second wet seasons (CFDS and CSWS), respectively (Table 4.22).

4.7.3 Jaccard's similarity indices of the species in the standing vegetation and Soil seed bank across seasons in the Buffer and Core zones of the Marguba Range of Old Oyo National Park, Nigeria

The highest resemblance between species composition of standing vegetation and soil seed bank was recorded in the Buffer zone in the seed bank and Core first dry (CFDS) in the standing vegetation and in Core first dry (CFDS) in the standing vegetation and Core second dry (CSDS) in the seed bank with common value 30.4%. The low similarity values were observed between Core second wet (CSWS) seed bank and Buffer second wet (BSWS) standing vegetation and Core second wet (CSWS) seed bank and Core first wet (CFWS) standing vegetation with common value of 8.2% (Table 4.23).

Table 4.21. Jaccard's similarity indices (%) among the standing vegetation across seasons in the Buffer and Core zones of the Marguba Range of Old Oyo National Park, Nigeria

Location	Seasonal Variations	Buffer					Core			
		BFWS	**BFDS**	**BSWS**	**BSDS**	**BW**	**CFWS**	**CFDS**	**CSWS**	**CSDS**
Buffer	**BFWS**									
	BFDS	10.7 (6)	0							
	BSWS	42.0 (29)	14.3 (6)	0						
	BSDS	11.9 (7)	45.5 (5)	18.8 (8)	0					
Core	**CFWS**	51.2 (42)	8.8 (6)	39.2 (31)	13.0 (9)		0			
	CFDS	13.8 (8)	66.7 (6)	21.4 (9)	46.2 (6)		11.6 (8)	0		
	CSWS	43.8 (32)	12.5 (6)	63.6 (35)	16.0 (8)		56.8 (42)	15.7 (8)	0	
	CSDS	13.3 (8)	54.5 (6)	20.5 (9)	50.0 (7)		12.9 (9)	72.7 (8)	20.8 (10)	0
	CW					44 (21)				

Footnote: Data in parenthesis is the number of species common to both zones per season

BFWS = Buffer first wet season; BFDS = Buffer first dry season; BSWS = Buffer second wet season; BSDS = Buffer second dry season; BW = Buffer woody.

CFWS = Core first wet season; CFDS = Core first dry season; CSWS = Core second wet season; CSDS = Core second dry season; CW = Core woody.

Table 4.22. Jaccard's similarity indices (%) for emerging plants from soil seed bank of the Buffer and Core zones of Marguba Range of Old Oyo National Park, Nigeria

Location	Seasonal variations	Buffer				Core			
		BFWS	BFDS	BSWS	BSDS	CFWS	CFDS	CSWS	CSDS
Buffer	BFWS	0							
	BFDS	61.5 (16)	0						
	BSWS	48.0 (12)	45.8 (11)	0					
	BSDS	34.4 (11)	32.3 (10)	33.3 (9)	0				
Core	CFWS	58.6 (17)	63.0 (17)	44.4 (12)	36.4 (12)	0			
	CFDS	63.3 (19)	51.6 (16)	35.5 (11)	37.1 (13)	59.4 (19)	0		
	CSWS	26.9 (7)	29.2 (7)	52.9 (9)	33.3 (8)	25.0 (7)	26.6 (8)	0	
	CSDS	38.7 (12)	36.7 (11)	33.3 (9)	55.6 (15)	36.4 (12)	45.5 (15)	33.3 (8)	0

Footnote: Data in parenthesis is the number of species common to both zones per season

BFWS = Buffer first wet season; BFDS = Buffer first dry season; BSWS = Buffer second wet season; BSDS = Buffer second dry season;

CFWS = Core first wet season; CFDS = Core first dry season; CSWS = Core second wet season; CSDS = Core second dry season.

Table 4.23. Jaccard's similarity indices (%) for emerging plants from standing vegetation and soil seed bank of Buffer and Core zones of Marguba Range of Old Oyo National Park, Nigeria

Location	Seasonal variations	Soil seed bank							
		BFWS	**BFDS**	**BSWS**	**BSDS**	**CFWS**	**CFDS**	**CSWS**	**CSDS**
Standing Vegetation	**BFWS**	17.9 (12)	16.7 (11)	9.1 (6)	23.8 (15)	15.7 (11)	20.0 (14)	7.9 (5)	21.9 (14)
	BFDS	16.7 (4)	13.0 (3)	10.5 (2)	22.7 (5)	20.0 (5)	13.8 (4)	13.3 (2)	22.7 (5)
	BSWS	20.8 (11)	19.2 (10)	11.8 (6)	26.0 (13)	20.0 (11)	25.5 (14)	8.2 (4)	23.5 (12)
	BSDS	18.5 (5)	20.0 (5)	19.1(4)	29.2 (7)	21.4 (6)	15.6 (5)	23.5 (4)	29.2 (7)
	CFWS	16.9 (13)	15.8 (12)	12.2 (9)	21.9 (16)	16.5 (13)	17.3 (14)	8.2 (6)	18.7 (14)
	CFDS	19.2 (5)	16.0 (4)	9.1 (2)	30.4 (7)	22.2 (6)	20.0 (6)	11.1 (2)	30.4 (7)
	CSWS	18.6 (11)	19.3 (11)	14.5 (8)	25.5 (14)	18.0 (11)	19.1 (12)	11.3 (6)	21.1 (12)
	CSDS	22.2 (6)	14.8 (4)	8.3 (2)	28.0 (7)	20.7 (6)	18.8 (6)	10.0 (2)	28.0 (7)

Footnote: Data in parenthesis is the number of species common to both zones per season

BFWS = Buffer first wet season; BFDS = Buffer first dry season; BSWS = Buffer second wet season; BSDS = Buffer second dry season;

CFWS = Core first wet season; CFDS = Core first dry season; CSWS = Core second wet season; CSDS = Core second dry season

4.8 Multivariate analysis of herbaceous species encountered during the wet and dry season in the Buffer and Core zones of the Marguba Range of Old Oyo National Park (OONP)

4.8.1 Cluster analysis of the herbaceous species in the Buffer and Core zones

There were 8 main dichotomies of flora groups, with the first cluster branching off at 1100 with one of the initial divisions in the positive dichotomy separating into associations of *Hyparrhenia involucrata* and *Aspilia bussei* at a Euclidean distance of 450 with *Chromolaena odorata* in a unique group branching off at 600 points. The second main division on the positive preferential side consisted of *Andropogon tectorum, Imperata cylindrica, Rottboellia cochinchinensis, Tephrosia bracteolata* and *Spigeia anthelmia* branching off at Euclidean distances of 380, 310, 250, 160 and 160, respectively (Figure 4.13).

The first cluster on the negative preferential side was a unique group branching off at a Euclidean distance of 450 (*Centella asiatica*), a second group included *Spermacoce octodon, Azolla pinnata, Tephrosia linearis* and *Panicum repens* branching off at 120, 80, 50 and 50. A larger group on the negative preferential side consisted of two main groups with the larger divisive association between *Senna obtusifolia, Phyllanthus pentandrus, Cyperus rotundus, Pueraria phasioloides, Sida rhomboidei, Centrosema pubescens, Scleria naumaniana* e.t.c. branching off between180 and zero. The smaller group consisted of *Panicum brevifolium, Setaria megaphylla, Tephrosia pedicellata, Ludwigia octavalvis, Oldenlandia corymbosa* and *Phyllanthus niruri* branching off between 180 and zero (Figure 4.13).

4.8.2 Detrended Correspondence Analysis (DCA) of the herbaceous flora in the buffer and core zones

The Detrended Correspondence Analysis (DCA) yielded a two-dimensional quadrat ordination for all the herbaceous species enumerated during the first and second year, wet and dry seasons, respectively (Figure 4.14). The points on the scatter gram corresponds to individual flora species and how they are related to one another by similarity or dissimilarity based on the distances between the points. The DCA biplots showed that the species as well as quadrats were similar as depicted by the clustering of the species defining them with a lot of redundancy in the biplot of both zones. The Buffer zone was distinctly different in outlying flora composition from the Core zone under the 95% ellipses, the outlying species in Axes 1 and 2 included *Brysocarpus coccineus*, *Manihot esculentus*, *Celosia argentia* and *Smilax anceps* with eigenvalue between 0.52 and 0.28 (Figure 4.14).

4.8.3 Species Packing of herbaceous flora in the buffer and core zones

The species encountered a normal distribution with some species being evenly spread across the study location while some were arched at a certain angle toward the negative preferential condition (Figure 4.15). The evenly distributed species were spread across positive preferential conditions across the Core and Buffer zone.

4.8.4 Cluster analysis of the woody species in the Buffer and Core zones of Marguba Range of OONP

The dendogram of classification of the woody species of the Buffer and Core zones based on woody species association indicated there were eight groups of division which later got divided from the highest level to the lowest level of divisiveness. *Lophira lanceolata* (18) and *Piliostigma thonningii* (18) were the first group on the negative dichotomy branching off at a Euclidean distance of 57 followed by a lone group (*Detarium velutinum*) at a Euclidean distance of 45. The first group on the positive preferential branched off at a Euclidean distance of 42 comprising of *Anogeissus leiocarpus* (24), *Nauclea latifolia* (22), *Khaya grandifoliola* (18), *Burkea Africana* (13), *Cussonia barteri* (12), *Grewia mollis* (11), *Combretum collinum* and *Daniella oliveri* (5). The fourth dichotomy is on the negative preferential and separated into associations of *Ficus exasperata* (10), *Pterocarpus erinaceus* (6), and *Entada africana* and *Acacia sieberiana* (4) branching off at a Euclidean distance of 31. The second dichotomy on the positive preferential branched off at a Euclidean distance of 28 comprising of *Terminalia macroptera* (13), *Pseudocedrella kotschyii* (12), *Gardenia aqualla* (6), *Annona seneghalensis* (6), *Detarium microcarpum* (3), *Psorospermum febrifugum* (3). The result indicated that the woody species encountered at the Buffer and Core zones of Marguba Range of Old Oyo National Park were closely associated (Figure 4.16).

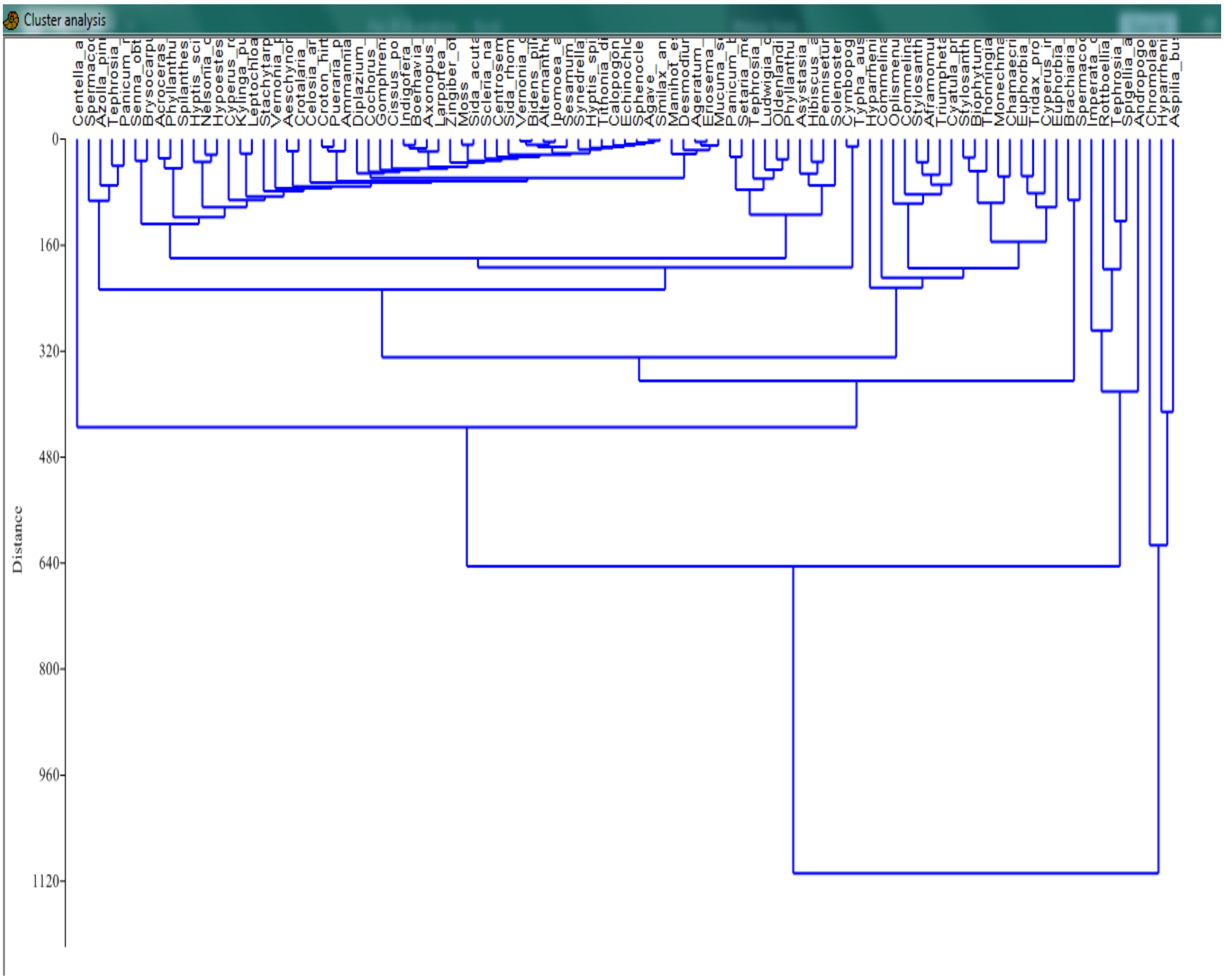

Figure 4.13. **Dendogram of phytosociology of the herbaceous species in the Buffer and Core zones of Marguba range of OONP, Nigeria**

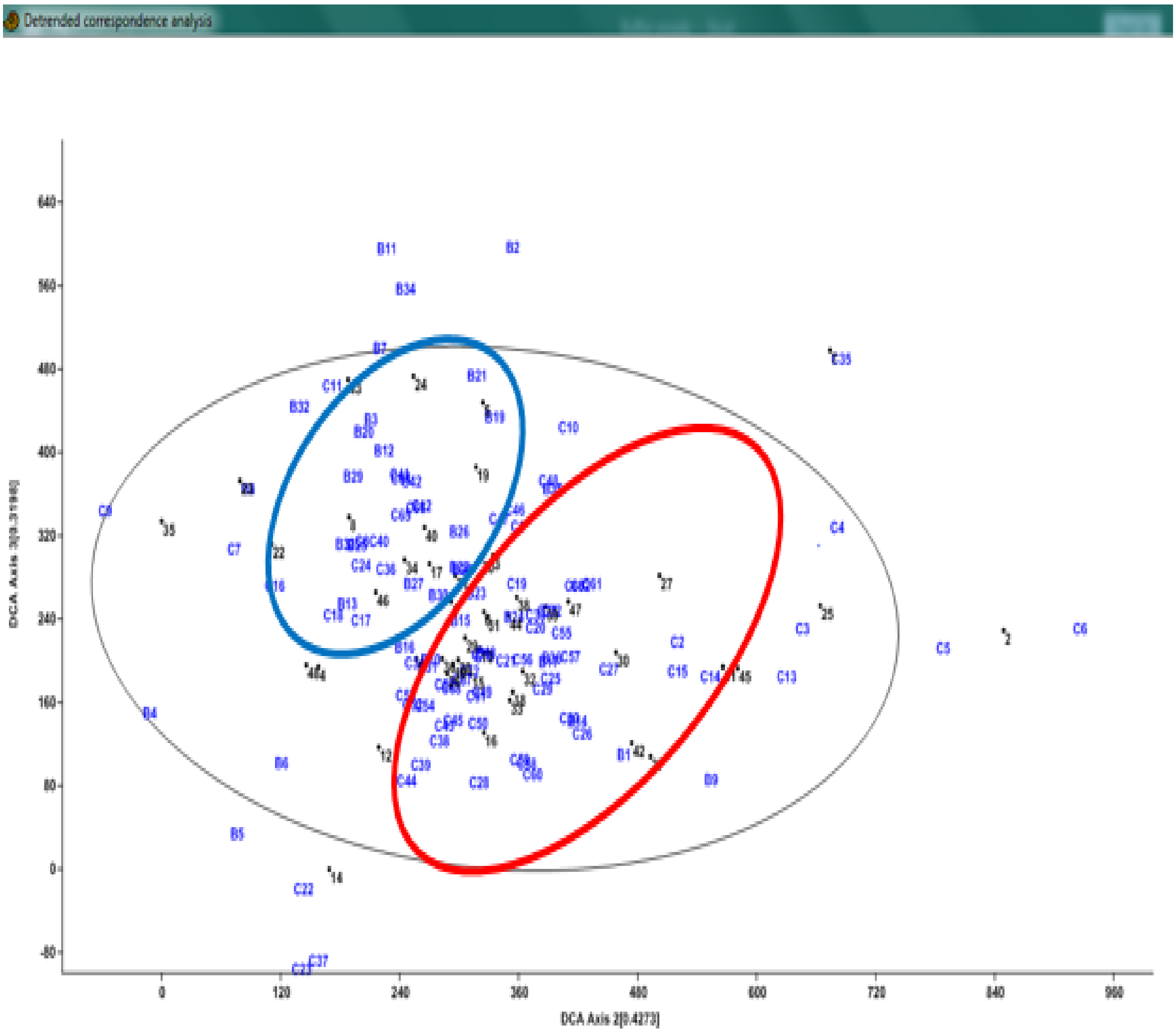

Figure 4.14. Detrended Correspondence Analysis of the herbaceous flora in the Buffer (B)and Core zones (C) of Marguba Range of OONP, Nigeria

1*Acro ziza*	**11***Axon comp*	**21***Cent pube*	**31***Cymb giga*	**41***Hibi aspe*	**51***Lept fili*	**61***Penn poly*	**71***Sida rhom*	**81***Styl hama*	**91***Vern gala*
2*Aesc indi*	**12***Azol pinn*	**22***Cham mimo*	**32***Cype iria*	**42***Hypa invo*	**52***Ludw octa*	**62***Phyl niru*	**72***Smil ance*	**82***Syne nudi*	**92***Vern perr*
3*Afra scep*	**13***Bide pilo*	**23***Chro odor*	**33***Cype rotu*	**43***Hypa rufa*	**53***Mani escu*	**63***Phyl pent*	**73***Sole mono*	**83***Teph brac*	**93***Zing offi*
4*Agave*	**14***Biop pete*	**24***Ciss popu*	**34***Desm scor*	**44***Hypo canc*	**54***Mone cili*	**64***Puer phas*	**74***Sper octo*	**84***Teph line*	
5*Ager cony*	**15***Boer diff*	**25***Corc trid*	**35***Dipl samm*	**45***Hypt spic*	**55***Mucu sola*	**65***Rott coch*	**75***Sper ocym*	**85***Teph pedi*	
6*Alte sess*	**16***Brac defl*	**26***Comm beng*	**36***Echi pyra*	**46***Impe cyli*	**56***Nels cane*	**66***Scle naum*	**76***Sphe zeyl*	**86***Thon sang*	
7*Amma bacc*	**17***Brys cocc*	**27***Comm erec*	**37***Erio psol*	**47***Indi hirs*	**57***Olde cory*	**67***Senn obtu*	**77***Spig anth*	**87***Tith dive*	
8*Andr tect*	**18***Calo mucu*	**28***Crot macr*	**38***Euph hirt*	**48***Ipom aqua*	**58***Opli burm*	**68***Sesa indi*	**78***Spil cost*	**88***Trid proc*	
9*Aspi buss*	**19***Celo arge*	**29***Crot hirt*	**39***Euph hyss*	**49***Kyli pumi*	**59***Pani brev*	**69***Seta mega*	**79***Stac caye*	**89***Triu rhom*	
10*Asys gang*	**20***Cent asia*	**30***Cyat pros*	**40***Gomp celo*	**50***Larp aest*	**60***Pani repe*	**70***Sida acut*	**80***Styl guia*	**90***Typh aust*	

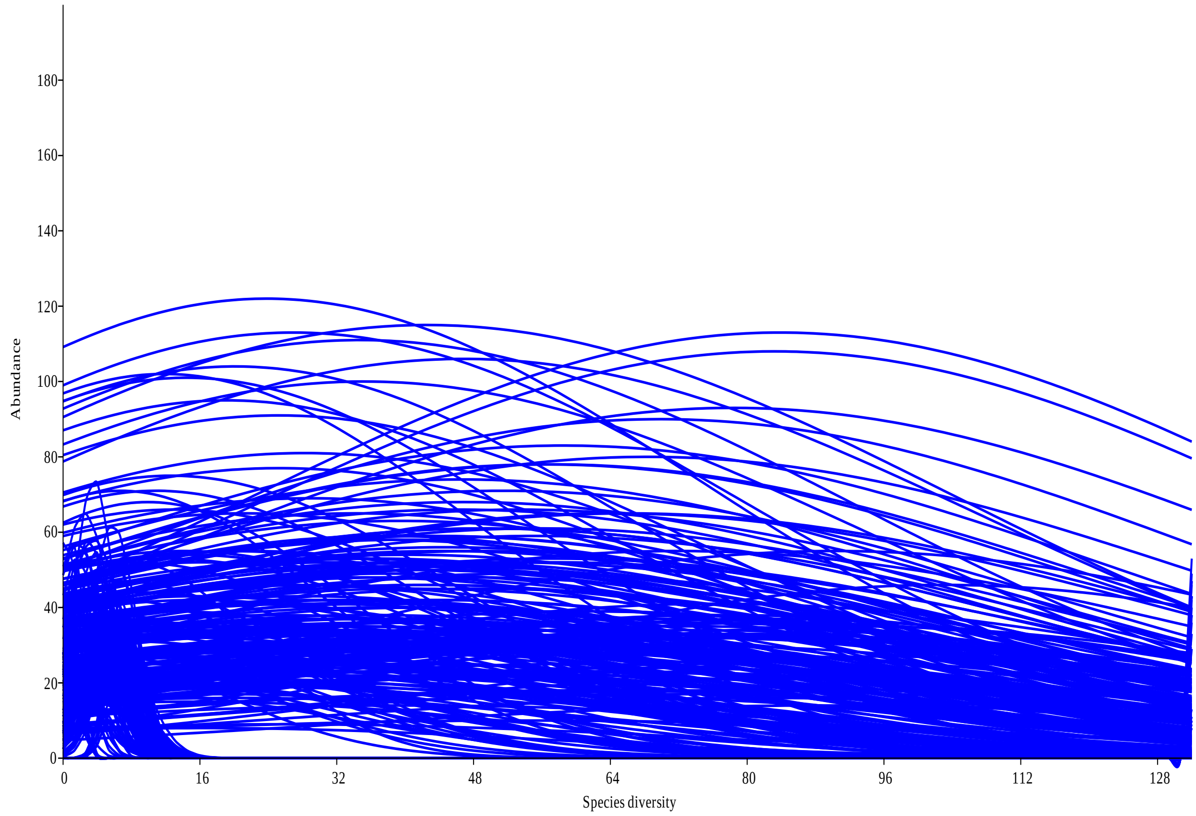

Figure 4.15. Gradient species packing of the herbaceous species enumerated in the Core and Buffer zones of the Marguba range Old Oyo National Park, Nigeria

4.8.5 Detrended Correspondence of woody species encountered in the Buffer and Core zones of Marguba Range of OONP

The Detrended Correspondence Analysis (DCA) yielded a two-dimensional quadrat ordination for all the woody species encountered as shown in Figure 4.17. The point on the scattered diagram corresponds to individual woody species and how they are related to one another by similarity or dissimilarity based on the distances between the points. The DCA biplots showed that the species as well as quadrats were similar as depicted by the clustering of the species defining them with a lot of redundancy in the biplot of both zones. With 95% ellipses, the outlying species included *Afzelia africana*, *Entada africana*, and *Acacia sieberiana* with eigenvalue between 0.58 and 0.42 (Figure 4.17).

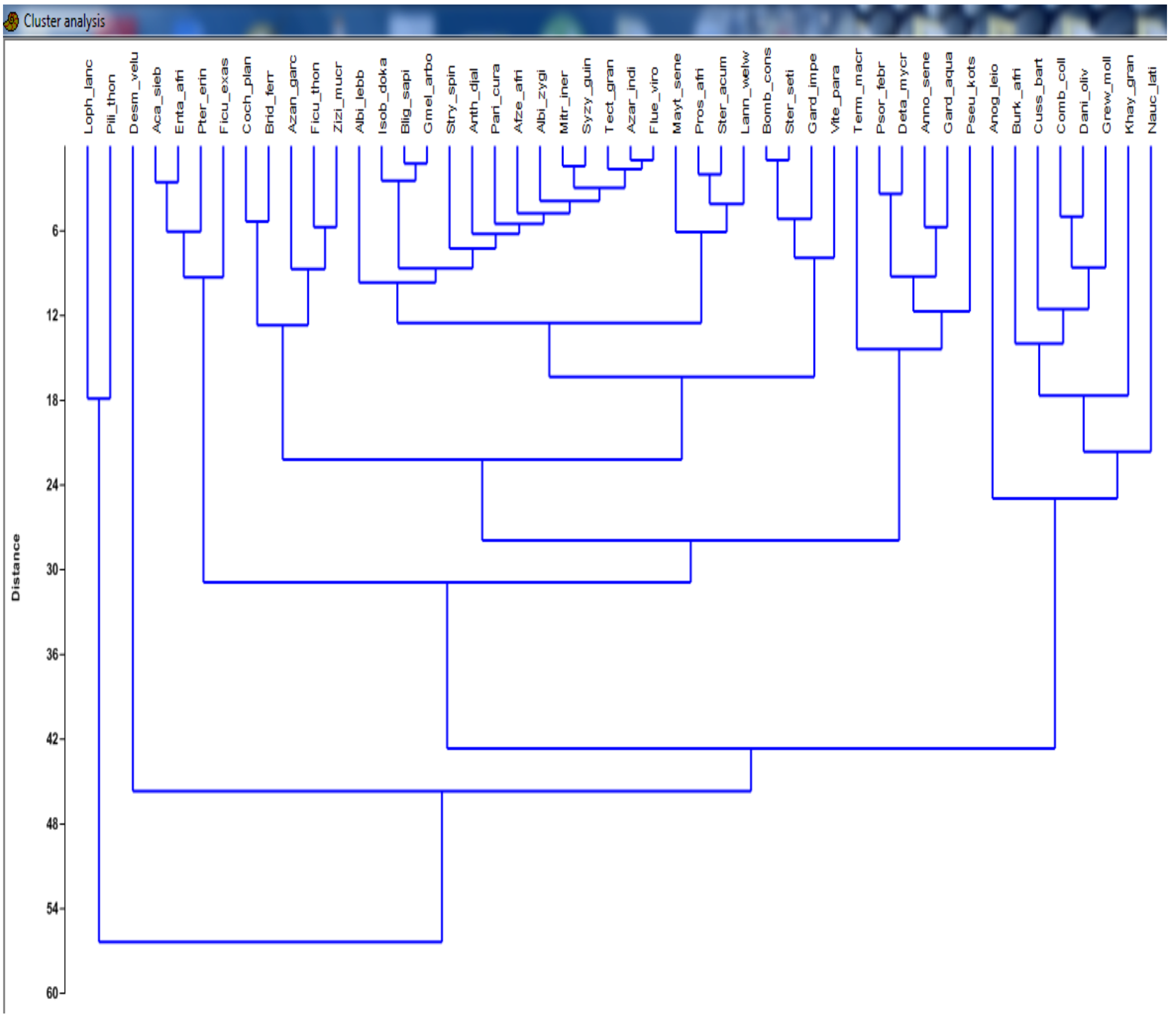

Figure 4.16. **Dendogram of phytosociology of the woody flora of the Buffer and Core zone of the Marguba Range of Old Oyo National Park, Nigeria**

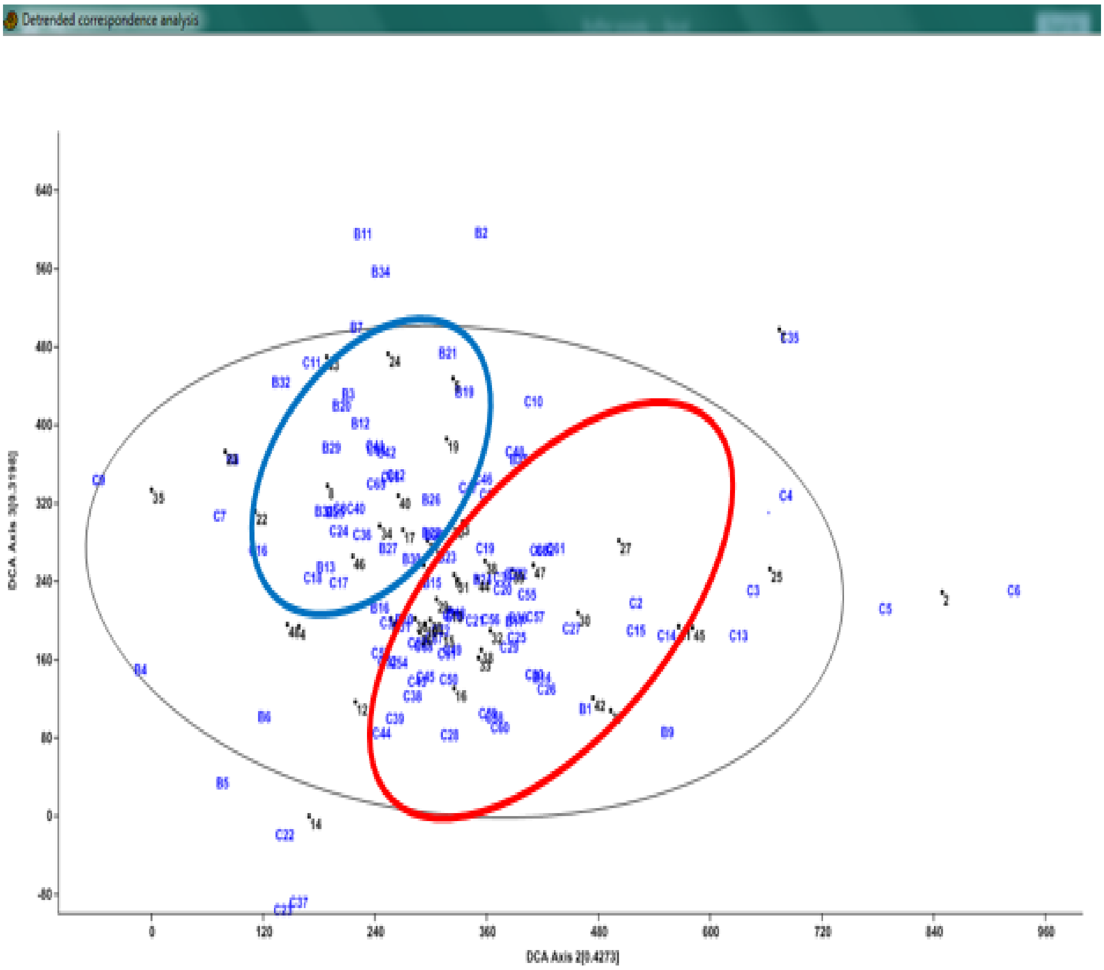

Figure 4.17. Detrended Correspondence Analysis of woody species in the Buffer (B) and Core zones (C) of Marguba range of Old Oyo National Park, Nigeria

1 *Acac sieb*	**11** *Bomb cons*	**21** *Ficu exas*	**31** *Loph lanc*	**41** *Ster seti*
2 *Afze afri*	**12** *Brid ferr*	**22** *Ficu thon*	**32** *Mayt sene*	**42** *Ster acum*
3 *Albi lebb*	**13** *Burk afri*	**23** *Flue viro*	**33** *Mitr iner*	**43** *Stry spin*
4 *Albi zygi*	**14** *Coch plan*	**24** *Gard aqua*	**34** *Nauc lati*	**44** *Syzy guin*
5 *Anno sene*	**15** *Comb coll*	**25** *Gard impe*	**35** *Pari cura*	**45** *Tect gran*
6 *Anog leio*	**16** *Cuss bart*	**26** *Gmel arbo*	**36** *Pili thon*	**46** *Term macr*
7 *Anth djal*	**17** *Dani oliv*	**27** *Grew moll*	**37** *Pros afri*	**47** *Vite para*
8 *Azan garc*	**18** *Desm velu*	**28** *Isob doka*	**38** *Pseu kots*	**48** *Zizi mucr*
9 *Azar indi*	**19** *Deta mycr*	**29** *Khay gran*	**39** *Psor febr*	
10 *Blig sapi*	**20** *Enta afri*	**30** *Lann welw*	**40** *Pter erin*	

4.9 Diameters at breast height (D.B.H.) and Height (m) of the woody species composition of the Buffer and Core zones of the Marguba Range of Old Oyo National Park

4.9.1 Mean Diameter at Breast Height of woody species ≥ 10 cm in the Buffer and Core zone

Out of the 43 tree species enumerated in the study area, only 26 was recorded in the Buffer and 37 in the Core zone. In the buffer zone, *Acacia sieberiana* had the highest mean D.B.H. of 41.38 cm/ha closely followed by *Vitellaria paradoxa* (38.45 cm/ha), *Daniella oliveri* (32.07 cm/ha), *Entada africana* (31.58 cm/ha) and the species with least mean D.B.H. were *Strycnos inopa* (12.25 cm/ha) followed by *Gardenia aqualla* (11.70 cm/ha) (Table 4.24).

In the core zone, *Piliostigma thonningii* had the highest mean D.B.H. of 75.30 cm/ha which is the highest among all the species encountered in the study area, followed by *Daniella oliveri* (46.27 cm/ha); *Nauclea latifolia* (44.66 cm/ha); and *Sterculia setigera* (39.71 cm/ha) while the species with the least mean D.B.H. were *Gardenia aqualla* (17.90 cm/ha) followed by *Pterocarpus erinaceus* (15.09 cm/ha). Generally, among the studied plots, the core zone recorded trees with higher total mean D.B.H. than the buffer zone with 1035.28 ± 2.23 cm/ha and 609.98 ± 2.094 cm/ha, respectively (Table 4.24).

4.9.2 Mean heights of woody species in the study area

The Core zone recorded a total mean height of 189.80 ± 0.39 m/ha and the Buffer zone 179.74 ± 0.70 m/ha. However, individual tree heights showed buffer zone trees had higher mean heights than trees in the core zone. These species include *Acacia sieberiana* (18.70 m/ha), *Daniella oliveri* (11.68 m/ha), *Albizia zygia* (11.13 m/ha), *Vitellaria paradoxa* (10.70 m/ha), *Pseudocedrella kotschyii* (10.63 m/ha), and species in the Core zone were *Afzelia africana* (9.83 m/ha), *Tectona grandis* (9.00 m/ha) and *Daniella oliveri* (8.08 m/ha) (Table 4.24).

4.9.3 Distribution of woody species in the Buffer and Core zones according to D.B.H. size class

In the Buffer zones, diameter at breast hights (D.B.H.) class 21-30 cm had the highest family and species inventory of 7 (11) followed by class size 11-20 cm with 8 (9) while the least was recorded for class size 41-50 cm which had 1 (1) family and species, respectively (Figure 4.18).

In the Core zone, woody species with class size 21-30 cm recorded 13 (18) family and species, respectively followed by class size 11- 20 cm with 6 (8) while the least was

Table 4.24. Mean Diameter at breast height (D.B.H.), and Height (m) of the tree species composition of Buffer and Core zones of the Marguba Range of Old Oyo National Park, Nigeria

S/N	Woody species	D.B.H. ≥ 10cm		Height (m)	
		Buffer	Core	Buffer	Core
1	*Acacia sieberiana*	41.38	-	18.70	-
2	*Afzellia Africana*	-	39.05	-	9.83
3	*Albizia lebbeck*	-	29.16	-	8.44
4	*Albizia zygia*	29.60	36.82	11.13	6.00
5	*Annona senegalensis*	15.22	22.49	3.86	4.85
6	*Anogeissius leiocarpus*	27.41	24.14	10.51	5.50
7	*Anthocleista djalonensis*	-	20.69	-	7.20
8	*Azanza garckeana*	12.73	24.62	4.62	7.20
9	*Blighia sapida*	-	26.63	-	3.07
10	*Bombax constratum*	-	26.58	-	6.10
11	*Bridelia ferruginea*	-	23.43	-	2.82
12	*Burkea Africana*	30.66	31.06	9.00	5.73
13	*Combretum collinum*	-	26.78	-	4.20
14	*Cussonia barteri*	-	23.61	-	4.36
15	*Daniella oliveri*	32.07	46.27	11.68	8.08
16	*Detarium mycrocapum*	25.34	-	6.82	-
17	*Entada Africana*	31.58	-	5.48	-
18	*Ficus thonningii*	-	19.63	-	5.18
19	*Flueggea virosa*	16.07	-	3.85	-
20	*Gardenia aqualla*	11.70	17.90	3.05	3.35
21	*Gardenia imperialis*	-	18.70	-	4.28
22	*Gmelina arborea*	-	33.00	-	4.43
23	*Grewia mollis*	-	21.43	-	3.68
24	*Isoberlina doka*	-	29.28	-	4.06
25	*Khaya grandifoliola*	27.08	25.91	4.83	6.20
26	*Lannea welwitschia*	26.65	26.90	4.04	3.60
27	*Lophira lanceolata*	26.04	37.19	7.73	6.43
28	*Maytenus senegalensis*	12.99	22.88	3.40	3.21
29	*Mitragyna inermis*	-	20.21	-	2.35
30	*Nauclea latifolia*	14.18	44.66	2.62	6.21
31	*Parinari curatellifolia*	-	29.28	-	5.00
32	*Piliostigma thonningii*	22.35	75.30	7.46	4.46
33	*Prosopis africana*	31.30	-	9.47	-
34	*Pseudocedrela kotschyii*	26.66	20.64	10.63	4.10
35	*Pterocarpus erinaceus*	20.52	15.09	5.21	3.44
36	*Sterculia setigera*	-	39.71	-	5.43
37	*Stereospermum acuminatissimum*	30.88	-	8.88	-
38	*Strychnos spinosa*	12.25	-	3.15	-
39	*Syzygium guineense*	-	20.69	-	5.35
40	*Tectona grandis*	-	31.04	-	9.00
41	*Terminalia macroptera*	28.73	28.73	5.28	4.78
42	*Vitellaria paradoxa*	38.45	30.20	10.70	6.20
43	*Ziziphus mucronate*	18.14	25.57	7.65	5.70
	Total	609.98	1035.28	179.74	189.80
	S.E.	2.09	2.23	0.70	0.39

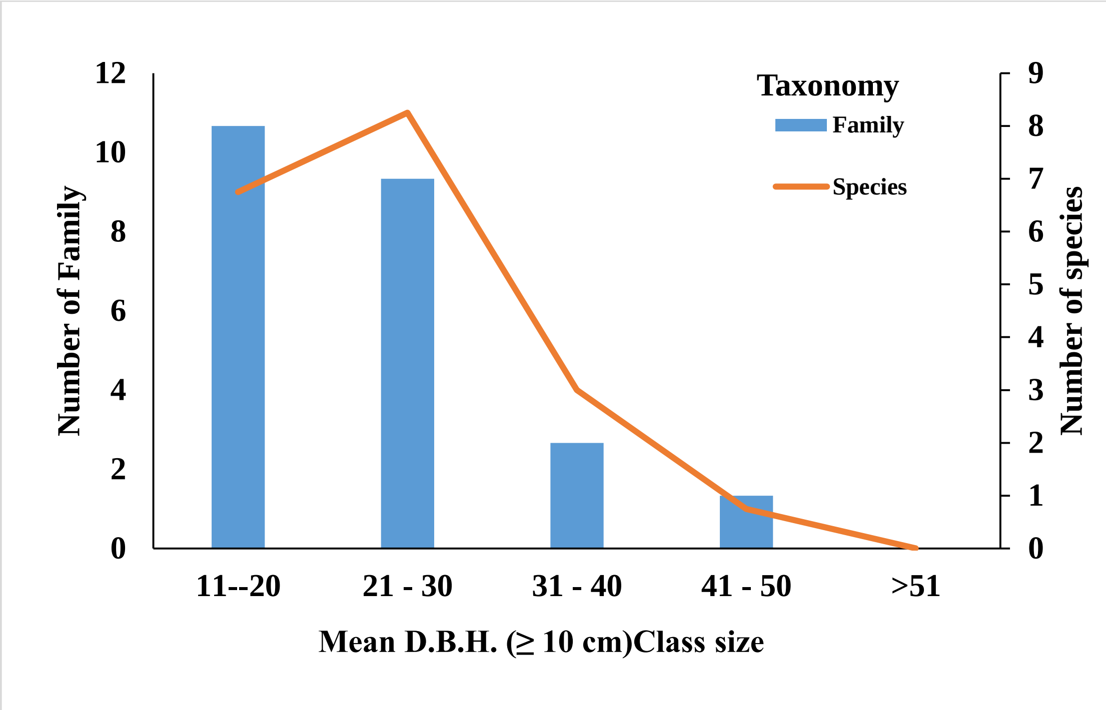

Figure 4.18. **The distribution of mean D.B.H. Class size for the trees enumerated per location according to number of family and species at the Buffer zone of the Marguba range of Old Oyo National Park, Nigeria**

recorded in class size greater that 51 cm which recorded 1 (1) family and species, respectively (Figure 4.19).

4.10 Biomass volume and carbon stock estimation of the woody species enumerated in the Buffer and Core zones of Marguba Range of OONP

The biomass volume and the carbon stock estimation in the Buffer and Core zone of the Marguba Range of Old Oyo National Park is shown on Table 4.25.

In all, 43 tree species were enumerated within the selected sampled plots. In the Buffer zone, the highest biomass and carbon stock were recorded in *Acacia sieberiana* (765.79 kg/ha/year and 0.40 t C/ha/year) followed by *Vitellaria paradoxa* with 645.89 kg/ha/year and 0.33 t C/ha/year, respectively. However, the lowest biomass and carbon stock were recorded in *Gardenia aqualla* (40.85 kg /ha/year and 0.02 t C/ha/year) followed by *Azanza garckaena* (49.72 kg/ha/year and 0.03 t C/ha/year), respectively.

In the Core zone, *Piliostigma thonningii* had the highest biomass (3071.05 kg/ha/year) and carbon stock (1.59 t C/ha/year) followed by *Daniella oliveri* with 992.41 kg/ha/year and 0.51 t C/ha/year, respectively while the lowest biomass and carbon stock were *Mitragyna inermis* (145.28 kg/ha/year and 0.08 t C/ha/year) followed by *Pterocarpus erinaceus* (73.72 kg/ha/year and 0.04 t C/ha/year) (Table 4.25). The total biomass and carbon stock of woody species enumerated in the study area was estimated at 6595.09 kg/ha/year and 3.41 t C/ha/year for Buffer zone and 14560.89 kg/ha/year and 7.53 t C/ha/year for Core zone, respectively (Table 4.25). The total carbon sequestered in the buffer zone and core zone were 12.52 t C/ha/year and 27.64 t C/ha/year, respectively.

4.11 Soil physicochemical parameters of sampled sites of the Marguba range of Old Oyo National Park, Nigeria

4.11.1 Soil Organic elements

The pH ranged between 6.59± 0.07 (Buffer) to 6.64±0.08 (Core). All the pH values showed the soils are slightly acidic, they are still relatively neutral, and this shows the samples ranged in the optimal pH range. For both sampled locations, the soil pH was not significantly different from that of the other.

Organic carbon ranged from 1.57 ±0.13 (Buffer) to 1.72± 0.12 (Core), the amount of organic carbon in each location was not significantly different from each other. This shows it is evenly distributed all around the sampled sites; same trend was observed for organic matter content with values ranging from 2.80±0.27 (Buffer) to 2.94±0.21 (Core).

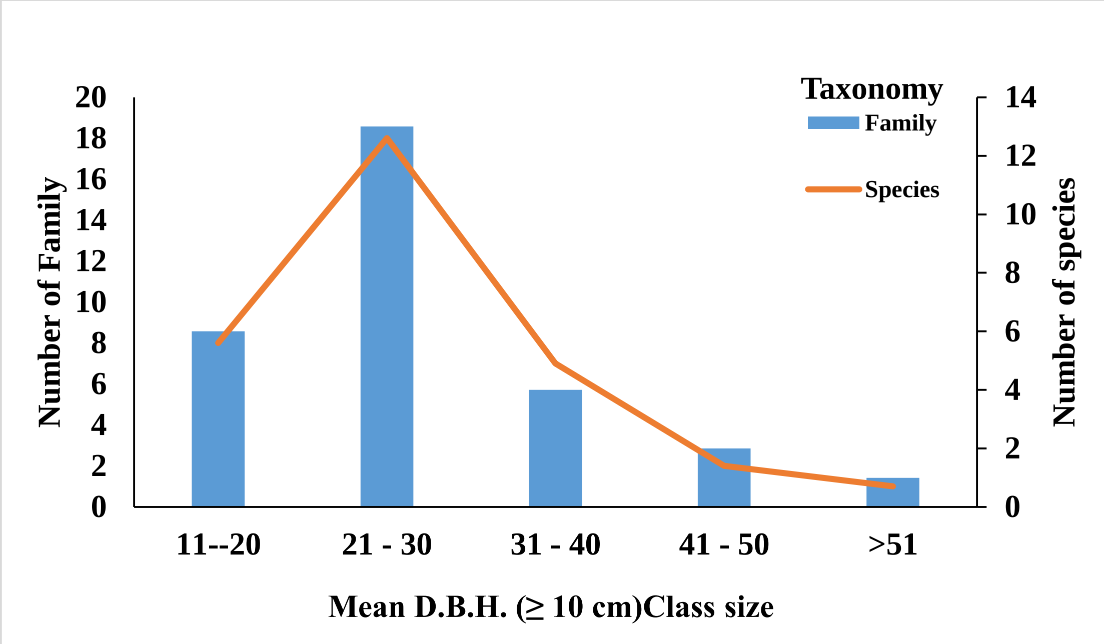

Figure 4.19. **The distribution of mean D.B.H. Class size for the trees enumerated per location according to number of family and species at the Core zones of the Marguba range of Old Oyo National Park, Nigeria**

Table 4.25. Estimated Biomass and Carbon stock of the enumerated trees in the Buffer and Core zones of the Marguba Range within Old Oyo National Park

	Woody species	D.B.H (cm)		Biomass (Kg/ha)		CS (tons/ha)	
		Buffer	Core	Buffer	Core	Buffer	Core
1	*Acacia sieberiana*	41.38	-	765.79	-	0.40	-
2	*Afzellia Africana*	-	39.05	-	669.28	-	0.35
3	*Albizia lebbeck*	-	29.16	-	339.98	-	0.18
4	*Albizia zygia*	29.60	36.82	352.08	584.07	0.18	0.30
5	*Annona senegalensis*	15.22	22.49	75.17	186.11	0.04	0.10
6	*Anogeissus leiocarpus*	27.41	24.14	294.51	219.33	0.15	0.11
7	*Anthocleista djalonensis*	-	20.69	-	153.36	-	0.08
8	*Azanza garckeana*	12.73	24.62	49.72	229.49	0.03	0.12
9	*Blighia sapida*	-	26.63	-	275.48	-	0.14
10	*Bombax constratum*	-	26.58	-	274.20	-	0.14
11	*Bridelia ferruginea*	-	23.43	-	204.61	-	0.11
12	*Burkea Africana*	30.66	31.06	382.05	393.61	0.20	0.20
13	*Combretum collinum*	-	26.78	-	279.13	-	0.14
14	*Cussonia barteri*	-	23.61	-	208.41	-	0.11
15	*Daniella oliveri*	32.07	46.27	423.93	992.41	0.22	0.51
16	*Detarium micocarpum*	25.34	-	245.40	-	0.13	-
17	*Entada Africana*	31.58	-	408.95	-	0.21	-
18	*Ficus thonningii*	-	19.63	-	135.74	-	0.07
19	*Flueggea virosa*	16.07	-	85.39	-	0.04	-
20	*Gardenia aqualla*	11.70	17.90	40.85	109.66	0.02	0.06
21	*Gardenia imperialis*	-	18.70	-	121.30	-	0.06
22	*Gmelina arborea*	-	33.00	-	452.94	-	0.23

S/N	Woody species	D. B. H. (cm)		Biomass (Kg/ha)		CS (tons/ha)	
		Buffer	Core	Buffer	Core	Buffer	Core
23	*Grewia mollis*	-	21.43	-	166.44	-	0.09
24	*Isoberlina doka*	-	29.28	-	343.36	-	0.18
25	*Khaya grandifoliola*	27.08	25.91	286.42	258.47	0.15	0.13
26	*Lannea welwitschia*	26.65	26.90	275.84	281.88	0.14	0.15
27	*Lophira lanceolate*	26.04	37.19	261.43	597.86	0.14	0.31
28	*Maytenus senegalensis*	12.99	22.88	52.06	193.65	0.03	0.10
29	*Mitragyna inermis*	-	20.21	-	145.28	-	0.08
30	*Nauclea latifolia*	14.18	44.66	63.88	914.09	0.03	0.47
31	*Parinari curatellifolia*	-	29.28	-	343.36	-	0.18
32	*Piliostigma thonningii*	22.35	75.30	183.34	3071.05	0.09	1.59
33	*Prosopis africana*	31.30	0.00	400.71	-	0.21	-
34	*Pseudocedrela kotschyi*	26.66	20.64	276.11	152.58	0.14	0.08
35	*Pterocarpus erinaceus*	20.52	15.09	150.39	73.72	0.08	0.04
36	*Sterculia setigera*	-	39.71	-	695.95	-	0.36
37	*Stereospermum acuminatissimum*	30.88	-	388.21	-	0.20	-
38	*Strychnos spinosa*	12.25	-	45.50	-	0.02	-
39	*Syzygium guineense*	-	20.69	-	153.36	-	0.08
40	*Tectona grandis*	-	31.04	-	392.87	-	0.20
41	*Terminalia macroptera*	28.73	28.73	328.40	328.40	0.17	0.17
42	*Vitellaria paradoxa*	38.45	30.20	645.89	368.77	0.33	0.19
43	*Ziziphus mucronate*	18.14	25.57	113.08	250.68	0.06	0.13
	Total	609.98	1035.28	6595.09	14560.89	3.41	7.53

Footnote: - =Nil; S.E. = Standard Error

Total Nitrogen showed there was no significant difference in its content by study area and its value ranged from 0.25±0.11 (Buffer) to 0.09±0.01 (Core) (Table 4.26).

4.11.1.1 Micro and Macro-elements

The potassium (K) content ranged from 0.01±0.00 to 0.02±0.01 Cmol/kg; the sodium (Na) content ranged from 1.17±0.18 to 0.90±0.07 Cmol/kg; Calcium (Ca) content ranged from 0.73±0.21 to 0.89±0.18 Cmol/kg; Exchangeable bases (EC) ranged from 1.19±0.36 to 1.81±0.19 Cmol/kg; Magnesium (Mn) ranged from 48.75±3.73 to 68.42±2.15 Mg/kg and it showed significant difference with Core zone having higher content of Mn; Copper (Cu) content in the sampled plots ranged from 2.45±0.31 to 1.53±0.13 Mg/kg with significant difference; Zinc (Zn) followed the same trend with significant difference across location ranging from 2.40±0.33 to 12.48±2.03 Mg/kg; Iron (Fe) content ranged from 45.31±7.24 to 52.55±8.20 Mg/kg; and Phosphorus (P) content was significantly higher for Core zone (58.37±7.87 Mg/kg) and Buffer zone (19.93±2.98 Mg/kg). There was significant difference in some parameters in the sampled locations. This further revealed the soil sampled are different in respect to the physical-chemical content (Table 4.26).

4.11.1.2 Textural Class

There was no significance difference between the soil texture of the Buffer and Core zones with textural class ranging from Sandy-loam to Loam-sandy, respectively. The sand content ranged from 84.83±1.52 (Buffer) to 87.12±0.83% (Core); the clay content ranged from 11.53±0.70 (Buffer) to 10.95±0.47% (Core); the silt content ranged from 3.92±0.96 (Buffer) to 2.98±0.52% (Core) (Table 4.26).

Table 4.26. Soil Physical and Chemical components (Mean ± Standard error) of the Buffer and Core Zones of the Marguba Range of Old Oyo National Park

Parameters	Buffer	Core	LSD
pH (1:1)	6.59±0.07a	6.64±0.08a	0.22
O.C.%	1.57±0.13a	1.72±0.12a	0.36
O.M.%	2.80±0.27a	2.94±0.21a	0.71
TN%	0.25±0.11a	0.09±0.01a	0.22
K (Cmol/kg)	0.01±0.00a	0.02±0.01a	0.02
Na (Cmol/kg)	1.17±0.18a	0.90±0.07a	0.39
Ca (Cmol/kg)	0.73±0.21a	0.89±0.18a	0.58
CEC	1.91±0.36a	1.81±0.19a	0.83
Mn (Mg/kg)	48.75±3.73b	68.42±2.15a	8.93
Cu (Mg/kg)	2.45±0.31a	1.53±0.13b	0.69
Zn (Mg/kg)	2.40±0.33b	12.48±2.03a	4.26
Fe (Mg/kg)	45.31±7.24a	52.55±8.20a	22.69
P (Mg/kg)	19.93±2.98b	58.37±7.87a	17.45
Sand (%)	84.83±1.52a	87.12±0.83a	3.60
Clay (%)	11.53±0.70a	10.95±0.47a	1.76
Silt (%)	3.92±0.96a	2.98±0.52a	2.26
Textural class	LS	SL	

Footnote: LS – Loamy sand, SL – Sandy loam.

CHAPTER FIVE

DISCUSSION

5.1 Demographic characteristics and Perception of People towards OONP activities

The mean age of respondents (30.74 years) and age group of 20 to 50 years, (52.4%) implied that the farming population comprised of active individuals of youthful age. Leavy and Smith (2010) reported that persons of this age are energetic and potentially encourage active farmland expansion. This has serious consequences for the Park, as more individuals seek for farmlands, however, provision of good conservation education to these youths may engender sustainable farming and probable compliance to rules bothering on conservation (Toomey *et al.*, 2017).

A greater proportion (69%) of the respondents were male and the gender distribution gives credence to the fact that the males are more involved in farming than females in Africa, because as the head of a family, it is a man's duty in African traditional settings to feed his family. The labour and energy demand of farming is implicated in this case and this suggestion corroborates the work of Okonya *et al*. (2013) who discovered in Uganda that households headed by females are less likely to get by than male-headed households. With more male respondents than female, it implies that the households still had husbands as the head of the house, nonetheless, involvements of few females as respondents could be a way of increasing the family income to combat poverty. The respondents had family members of 4-6 persons. This suggests that the farmers are more likely to practice subsistence farming, because of the low number of individuals they have to fend for. Household heads do not have to struggle too hard to fend for their families which could suggest that higher number of family members could create struggles for household heads and ability to feed their dependent family members.

In the study area, the respondents had low levels of education (5%) and are more likely to be involved in unskilled and informal or artisanal jobs. This was alluded to by a participant that they did not get the Park ranger jobs because they did not meet the requirements for employment.

Respondent generally indicated that during the process of land clearing, trees were felled and collected for fuelwood (Charcoal and firewood) and medicinal purposes, thus land was gradually being cleared for agricultural purposes which is invariably depleting forest and its resources in Africa (Valentini *et al*., 2014). The most prevalent economic activity among the locals was crop production and livestock rearing. Most agriculturalists breed their cattle and want to hold huge numbers with minute food source especially during dry season. This sometimes push their search for feed for their cattle into the buffer zone, this activity is detrimental to the survival of plants in the ecosystem, as a result of soil compaction.

In the study area, firewood and charcoal are the most important sources of energy and they are identified as the major causes of forest cover change, in a study carried out in Uganda's protected tropical mountain forest, reiterated that local dwellers around protected areas depend on them for fuelwood (Sassen *et al*., 2015), and the extraction impacts the savanna's biodiversity, structure and function. Massive woody plants are carefully harvested for fuelwood and logs by humans. And since large woody plants are selectively removed, the woodlands' basal area diminishes at a considerably quicker pace than the density of woody plant species. Additionally, once the desired big woody plants have been depleted, the less desired small woody plants are excised to fulfil the rising demands for fuelwood, thus lowering the basal area of the surviving woodland vegetation. Over the years, there has been an increase in the commercialization of firewood as its demand increased. The knowledge of respondents' fuelwood use was very high which means they were informed and probably aware of their impacts on the environment. Additionally, the sale of timber and fuelwood products are resources to generate revenue by resource deprived people such as women and jobless youths. Their perception towards fuelwood use was favourable which could suggest they considered it as their means of livelihood and would embrace its conservation. Their preference for firewood could suggest underlying reasons which could be its immediate use as a fuel source than waiting to process it into charcoal for use (Adekunle, 2006). However, there was no strong relationship between respondents' knowledge and perception of fuelwood use. The tree species reported to be used are of high economic importance (Adewumi *et al*., 2018) and should be conserved for sustainability, therefore, if pressures on them are not minimised, they could be lost.

The respondents acknowledged that afforestation and efficient use of resources would help alleviate the effects of climate change (Sassen *et al*., 2015). Poverty was identified as a factor that caused increased tree felling. This could be further linked to the reason why association of their knowledge of use of fuelwood and perception of the implication of use was low. The respondents had a positive disposition to the forest ecosystem and they understood what conservation was. There is awareness of the importance to conserve natural resources and not because the management enlightened them. Local community participation in forest management has been shown to improve environmental effects in Sub-Saharan Africa (MacKenzie *et al*., 2012). In tropical forested protected areas, the management must take into account both the demands of the local community as well as the consequences of using the forest resources.

The presence of conflict between local dwellers and Park management was a major challenge. Sodhi *et al*. (2010), opined that local communities in four Southeast Asian nations acknowledged the effectiveness of certain environmental services and their functions, yet conflicts existed between them and the management. Schonewald-Cox *et al*. (1992) advocated that management of National Parks and surrounding lands should be cross-bounded. Therefore, understanding the perception of local dwellers to human-wildlife conflict is important for conservation (Allendorf *et al*., 2012; Mojo, 2020). This study reported the presence of such conflicts emanating from animals destroying crops on farmlands buffering their habitat (Long *et al*., 2020). This has led to poaching as revealed by respondents indicating that poaching was allowed as reflected in killings of wildlife found on their farmlands. However, respondents further stressed that there was no proper awareness, and whatever view they had of conservation was their perception of the natural resource conservation. Berghoefer *et al*. (2010) also noted that a differentiated view should be applied to local awareness concerning natural resources. Degradation caused by human activities is severe and alarming within and around protected area (Adenle *et al*., 2020). This development is alarming because there are restrictions to entering the protected area, although this protection rules may not have been adequately enforced. It has also been suggested that resources are better conserved when locals are allowed to use and value them as part of their livelihood (Mojo, 2020). This is not the case in OONP, hence the conflicts arising between Park staff and the local communities. However, Kundu *et al*. (2017) opined that introducing the status of protected areas would help tackle the impactful human activities.

5.2 Land use/Land cover classification of Marguba Range of Old Oyo National Park

The comparatively low accuracy score observed in Bare ground/Rocky outcrops, Shrubland and Wetland were because of misclassification of the Bare ground and Shrubland because their spectral range were similar while the wetland's low score could be as a result of unclarity due to resolution. The result obtained in this study was in accordance with that of Fetene (2019).

Land degradation can occur on account of changes in usage and cover of the land, this manifests itself in variety of ways dependent on the rate of change. Wooded vegetation for instance, which provides fuel and feed, is becoming more and more rare, sources of water are running dry, and soils are becoming degraded. These effects could have a big impact on land users and those who rely on a healthy environment for their livelihood.

The change detected in the Marguba Range of Old Oyo National Park according to the classified classes between 1990 and 2019, especially in the core zone, revealed that forest, shrubland/grassland, bare surface/rocky outcrop, wetland and built-up were naturally transformed. This has harmful influence on the environment as well as socioeconomic conditions of the study area. For instance, the expansion of the bare surface/rocky outcrop was at the expense of the shrubland/grassland. This has however deteriorated and degraded the land greatly, especially in the buffer zone. The shrubland/grassland had reduced enormously from 1990 to 2019, and this could have resulted in reduction of wildlife species in the study area. Between 1990 and 2019, the shrubland/grassland lost an area of (-724.83 ha/year) to other land use types. This negates the results of Kafi *et al*. (2014) who stated that shrubland/grassland has increased over the last decade in Bauchi city. This loss could be attributed to human factor which was evident in landmarks and hunter's camps that were sighted in the park.

Susceptibility to degradation of the forests is understood that anthropogenic activities can affect or destroy forest resources. Currently, forest resources are also prone to natural factors not only human activities. The satellite image analysis showed that forest cover in both core and buffer zones decreased over the years indicating deforestation. This result supports the findings of Mehring and Stoll-Kleemann (2011) who indicated that parks are ineffective in reducing deforestation but refutes the findings of Bruner *et al*. (2001) who opined that Parks have good conservation potentials.

Observations of land cover loss could be as a result of seasonal changes throughout the satellite image recordings instead of other local factors.

Changes in land use/land cover reflect the socio-economic condition of the given area. In this situation, the poor are forced to extract natural resources for their upkeep affecting the standing vegetation and reducing the land cover. The observed hunters camp and other anthropogenic activities in the park corroborates the work of Fetene *et al*. (2019) that human landscape modification has resulted in widespread habitat alteration. The farmlands at the buffer zones of the park could be responsible for the loss of some species and introduction of new species. This is in accordance with the findings of Mengistu (2011) that expansion of agricultural land is partially responsible for the disappearance of biodiversity.

Decrease in rainfall over the years reflected the effects of climate change and this might have forced people to leave their farmland to open up new areas, therefore causing forest conversion at the local scale. UNEP (1992) stated that forest covers help in the regulation of soil water, biodiversity, carbon sequestration and habitat regulation for wildlife. A reduction in forest generally alters the normal functioning of ecosystems. This study also emphasised that the vegetal cover of Marguba Range of Old Oyo National Park has been negatively impacted and therefore biodiversity reduction may continue unless critical actions and policies were put in place. The greenness in 1990 was high in the Core zone with an observed reduction over the years. In 2019, the buffer zone's vegetal cover was almost completely gone and the loss of vegetal cover in the core zone could be attributed to increase in the bare surfaces/rocky outcrop observed. This is an indication that the number of impervious surfaces has increased from 1990.

5.3 Plant diversity of the Buffer and Core zones of Marguba Range of OONP

Broad ecological amplitude and greater adaptability can enhance survival of herbaceous species. There was variation in the species encountered between the first and second year of assessment. This could be due to grazing, fire, and herbivore activities, (McGranaham *et al*., 2013). The variations in community composition within vegetation structures might be associated with grazing. The overall herbaceous species abundance was boosted considerably by forb species. And it's in line with most of the phyto-diversity research in savanna and grassland ecosystems around the world (Koerner *et al*., 2014; Scott-Shaw and Morris, 2014). Eighty-four species from 29 families, nine species in Four families, 90 species in 24 families, 14 species in Eight families in the first wet season, first dry, second wet and second dry seasons, respectively, these recordings were made in the core and buffer zone. Due to the availability of favourable conditions, high species density and abundance were recorded during the rainy season than the dry season. Families such as Poaceae, Fabaceae, Euphorbiaceae and Asteraceae dominated the zones. Pereki *et al*. (2013) in Abdoulaye Wildlife Reserve in Togo that these families were the most common plant species in the natural habitats.

The occurrence of a main river, the Ibuya river, in the core zone might have contributed to the high species abundance and diversity of the ecosystem. Asase *et al*. (2012) indicated higher species richness in Ankasa reserve zone in Ghana with the presence of a river than the ones reported in previous studies carried out in the same location. *Aspilia bussei* was a pioneer species that has not been documented before in Old Oyo National Park. Its density and abundance were high across the studied area. Kohyama (1993) noted that pioneer species are indicators of disturbance and degradation.

The Park vegetation was degraded by overgrazing, and other factors, such as food insecurity, limited access to food markets, a large part of the population living in rural regions, and weak environmental governance. By virtue of the activities of the herdsmen and forest degradation, the buffer and core zones had become repositories for well-known invasive species such as *Chromolaena odorata*, *Imperata cylindrica* and *Aspilia bussei*. The invasion of the study site by *Chromolaena odorata* might have influenced the number of herbaceous species due to its ubiquitous nature in Africa. This was mentioned by Agboola and Joseph (2014) that a decrease in plant species composition and diversity was common in sites invaded by *Chromolaena odorata* and *Tithonia diversifolia*. The source of water in the core zone may be a pointer to dominance species that herds of cattle browse. Thus, invasive plant species might have gained entry to the core zone through the hooves and droppings of the livestocks (Porensky *et al*., 2020). The key causes of invasive species encroachment in natural environments are human activities.

There was even distribution of species in the study area, this was further enhanced by the Shannon-Wiener index which showed high species diversity in both study sites. Species encountered were dissimilar from buffer to core zone (8.8 – 46.2%) but was quite similar for the core zone (72.7%). However, there was high seasonal variations amongst the species encountered (Gatti *et al*., 2017). This suggest that areas close in perimeter can have presence of similar species which could be from cow dung, seed dispersal from natural processes or dispersed by ungulates in the park (Porensky *et al*., 2020).

Furthermore, no species dominated both zones in the dry season, this connotes high species richness, the species diversity was relatively low with high species evenness for the buffer and core zones. The variations in seasons and species diversity agrees with the report of Pearson and Dawson (2003) that suggested high species diversity of herbaceous species may be influenced by seasonal changes. The low diversity encountered in the dry season could mean that during seasons of dryness, seeds were distributed and conditions necessary for their germination was not available. Cazzolla *et al*. (2017) also suggested that measures of species richness do not always resemble the index of diversity. Thus, it is recommended that both abundance and other biodiversity indicators be considered carefully.

High woody species were recorded (48 species in 25 families) which indicates the floristic composition of savanna is variable even over relatively homogenous areas. This agrees with the study of Tom-Dery *et al*. (2012) who reported 50 species in 20 families in Damongo scarp in Northern Ghana which is a savanna ecosystem. This also agrees with Hemen *et al*. (2020) who recorded similar but lower species diversity (22 species) in the Edume derived savanna in Kogi state, Nigeria. Low woody species densities have been demonstrated to improve soil nutrient status and consequently support grass growth (Treydte *et al*., 2008), in conjunction with light penetration to favour the growth of low growing plants. This study recorded low density of woody species with easy penetration of light for the benefit of low growing species. Treydte *et al*. (2008) further explained how trees can assist grass development by enhancing nitrogen uptake in the wet season and delaying wilting in the dry season when trees are present in the grassland.

Family Fabaceae, Combretaceae, Rubiaceae, and Malvaceae were the most abundant in the core zone while Fabaceae and Meliaceae were present in the buffer zone, which partially supports the discovery of Hemen *et al*. (2020) in Nigeria who reported the presence of family Fabaceae, Rubiaceae and Malvaceae in the Edume derived savanna in Kogi state. Total number of Tree species encountered in the core zone was 41 (per hectare) and Buffer zone was 28 (per hectare). This does not support the findings of Asase *et al*. (2012) who analysed different tropical forests and reported 89-92 tree species per hectare in savanna ecosystem of Ghana and 56 tree species per hectare in savanna ecosystem of Uganda. This connotes that Old Oyo National Park was not within the range of this other West African reserves in terms of tree species composition. *Piliostigma thonningii, Lophira lanceolata* and *Anogeissus leiocarpus* were the most abundant species encountered in the core and buffer zone. This partially agrees with Pereki *et al*. (2013) who established that *Anogeissus leiocarpus* had the highest dominance in the protected area of Togo in the mosaic savannah forest studied.

Detarium microcarpum (Baboon biscuit) had a high abundance of seedlings and saplings in all the sampled plots. This may be related to its coping mechanisms to disturbances like fire, overexploitation, and grazing. This result supports the findings of Savadogo *et al*. (2017) who recorded low abundance of *Detarium microcarpum* in W National Park. This also indicates a high number being removed to cater for local needs as it arises probably through grazing activities. Its use as fuelwood and for construction, increases the economic benefits to local population (Hines and Eckman, 1993). This invariably implies that the regeneration and recruitment of the species was effectively implicated through fluctuating distribution pattern. Some tree species were abundant and ubiquitous, and they included *Vitellaria paradoxa, B. ferruginea, P. erinaceus, D. microcarpum* and *Pseudocedrela kotschyi*. This corroborates the findings of Savadogo *et al*. (2017) who reported them as resprouters.

Azardiratchta indica which is an exotic savanna species was common among the native savanna species such as *Afzelia africana*, *Lophira lanceolata*, and *Vitellaria paradoxa.* The IUCN Red List of Threatened Species classifies these tree species as vulnerable (IUCN, 2015). *Annona senegalensis* and *Gardenia aqualla* were the most frequently encountered shrub species, and this finding corroborates Maua *et al*. (2020) with family Rubiaceae as the most dominant. The study revealed more trees than shrubs, indicating wide distribution in the savanna.

Species with low Importance Value Index (IVI) (2.43 – 12.45) are of high concern for conservation as opined by Zegeye *et al*. (2006) and this study showed there were a lot of such species present both in the core and buffer zones. High IVI was observed in some species in Buffer and Core zones such as *Pseudocedrella Kotschyii*, *Cussonia barteri*, *Anogeissus leiocarpus*, *Burkea africana*, *Terminalia macroptera*, *Vitellaria paradoxa*, and *Grewia mollis*. The savanna vegetation is under threat from bushfires and grazing animals which promotes the spread of weeds. This suggests these vegetations should be protected against anthropogenic pressures to ensure their sustainable existence in the ecosystem (Zegeye *et al*., 2006).

The trees with highest mean heights in the buffer zone were those with high importance value index, suggesting that those trees were being preserved for economic benefits. Magurran (2013) recorded Shannon-Wiener index between 1.5 and 3.5 and rarely above 5.0 and the result observed in this study falls between these values.

Local causes of change can be implicated for land cover loss in the peripheral zone (boundary) and small sections of the core zone. This is because of close proximity of farmlands to the core zone and those present in the buffer zone. Since Park rangers patrol the core zone, farming activities in the buffer zone may not be noticed early enough for necessary action before mass expansion. Although, it has been documented that agricultural land abandonment is just beginning in the developing world, however, it helps with regeneration but cannot replace the ecosystems that had been lost, at least not for many years.

Generally, vegetation loss recorded both inside and outside protected areas in Nigeria is as a result of extensive anthropogenic activities (Fasona *et al*., 2016). Igbawua *et al*. (2016) reported the accelerators of land degradation in Nigeria as agricultural expansion, extraction of wood fuel, deforestation, and overgrazing. These pressures are implicated in biomass loss with eventual consequences for ecosystem services, leading to impoverishment. The biggest challenges impeding the park's functionality are clearly agricultural activities, grazing and the introduction of invasive species.

5.4 Seed bank of the Marguba Range of OONP, Nigeria

The biological diversity in the soil profile was comparable in the wet and dry seasons, however, more species were encountered in the dry season. Some of the most frequent occurring families were Poaceae, Asteraceae, Amaranthaceae, and Fabaceae and this supports the findings of De Andrade and Miranda (2014) who reported family Poaceae as the most abundant species after fire disturbances. Primarily, more herbaceous species were found in the soil seed bank, suggesting that they had a greater probability of regeneration than tree species. This could be due to the size of their seeds and the ease with which their seeds disperse. This corroborates the findings of (Baskin and Baskin, 2014) that herbaceous species seeds dominate in seed banks in seasonal environments.

The inability of the tree species to regenerate may be related to dormancy (Kassa *et al*., 2019). There is attributable evidence that woody plants produce enormous seeds that are difficult to bury, leaving them vulnerable to predators, scavengers, and fire (Savadogo *et al*., 2017). The abundance, density and species richness of seedlings of herbaceous plants represented in the seed bank also corroborates the findings of Senbeta and Teketay (2001) who stated that most of dominant tree species in Savanna-woodland ecosystem have no contribution to seed accumulation in the soil bank. Furthermore, the seed bank of the soil lacks conventional forest trees suggests that it cannot be used to recover forest tree species.

Chromolaena odorata was present in almost all the sampled plots in both seasons, Awodoyin *et al*. (2013) described *Chromolaena odorata* as one of the ubiquitous species that were invasive. Comparing the present study with Olubode *et al.* (2011), who recorded lower number of species in the wetlands of the core zone of Old Oyo National Park, some new species have emerged, adding to species recorded in the wetlands. These included *Aspilia bussei*, *Azolla pinnata*, *Diplazium sp, Cyperus rotundus*. The ubiquitous species in the seed bank were *Chromolaena odorata, Aspilia bussei, Hyparrhenia involucrate*. The absence of seasonal variations in their occurrence could be attributed to their invasive nature (Ohikhena and Awodoyin, 2012). *Chromolaena odorata*, since its introduction to Nigerian fields has been present which was also reported by Awodoyin *et al*. (2013). Herbaceous species seeds were found in all sampled plots of the studied period, and the seedling densities varied over time. Harpole and Tilman (2007) discovered that there is a negative relationship between soil fertility and plant species richness which negates the study of Gentry (1988) who suggested that species richness intensifies with soil fertility which corroborates theory of fertility effect of Dybzinski *et al*. (2008) and the findings of this study.

These findings demonstrate the importance of consistency and heterogeneity in seed bank assessments, quantification of seed germination success and temporal changes as it affects seed viability. This study substantially adds to the understanding of seed bank resilience. Seed banks are supposed to be a representation of above ground vegetation, and floristic sampling is the most important variable measured when studying seed bank and vegetation relationships. In this study, the similarity indices of both the seed bank and vegetation composition was low which indicates high spatial variations (Olubode *et al*., 2011). Hopfensperger (2007) reflecting differences in habitat conditions and stresses. Lower seed bank density was recorded in areas with barer grounds which aligns with the findings of Pugnaire and Lazaro (2000) who stated there was no seed propagule that could be responsible for germination.

This study added to the body of knowledge on transient plant species following seasonal seed bank dynamics, more seedlings emerged from soils collected in the dry season. This shows the soil seed bank is an effective profile for seed dispersal and eventual emergence. There was high co-dominance and relatively high diversity in the study area, However, there was high seasonal variations amongst the species encountered (Cazzolla *et al*., 2017), Thompson and Grime (2012) corroborated this by reporting that the seasonal variation of the seed number is more a feature of the seed than the environment.

Additionally, Shen *et al*. (2007) reported that the seasonal variability of individual species could be due to differences in species phenology. The species compositions of seedling emergence from soil seed bank for both seasons showed insignificant variations. This may be attributed to the dispersal of more seeds into the soil seed bank at the during dry season. The seeds so dispersed were going through the rest period (dormancy) in the dry season, awaiting favourable conditions. This is attributable to species abundance in soils collected in dry season. The seed dispersal process, the rapid establishment of seedling and the development of certain seeds may also have led to and affected the abundance and density of soil seed bank species. This study supports the work of Traba *et al*. (2004) that the highest seed density is located near the soil surface (Zhang *et al*., 2016). The standing vegetation and seed bank were dissimilar across seasons and locations (7.9-30.4%). Oke *et al*. (2013) reported that the low similarity is a pointer to the diversity and wealth of species of a resilient ecosystem. However, Schwab and Kiehl (2017) reported a high similarity between above ground and soil seed bank species. The low similarity in this study could be related to the fact that the history of species remained dormant in the study area.

Range of environmental and anthropogenic activities added to the success of some species which included grazing and natural seed dispersal mechanisms (Preen, 1995), this study corroborates Baskin and Baskin (2014) that for seed bank to function, the physiological and environmental conditions must be made available for germination to take place.

5.5 Carbon sequestration potential of the buffer and Core zones

The DBH and height distribution of woody species in the buffer zone were more evidently greater than the core zone, this could be as a result of more species diversity in the core zone which are still young and the conservation of certain vulnerable species in the buffer zone which are of good economic importance. According to Abiyou (2010), forest structure knowledge is critical for preserving good regeneration of depleted species. Different patterns emerged from analyses regarding the relative density distribution by DBH and height classes for woody species from the landscape site. Variations in population density can be shown by various patterns of species population structure.

According to the result organized from the DBH classes, tree species in class 21-30 cm/ha were more distributed and the lowest DBH distribution in class size ≥51 cm/ha, this revealed that the study area was primarily made up of young and regenerating plants species and also shows that older trees with a high DBH may be exploited by the local population for a variety of purposes, including fuelwood production.

Savannas have a lot of potential for carbon storage, both short and long term. Carbon is stored more efficiently in tropical ecosystems by big, long-lived species and species with thick wood. Similarly, the findings of this study revealed that species contribute disproportionately to the above-ground carbon store. Jha (2015) reported that the total woodland population could better clarify the forest stand status and increase the carbon sequestration potential. Comparison of tree diameter ranges with respect to the above ground accumulation of biomass which showed that woody species with a lesser diameter span possessed more density, but a reduced amount of biomass accumulated. At the other hand, woody species with larger thicknesses were low in number but had more accumulated biomass. As a result, there was an indirect association between woody species density and DBH, but there was a direct association between above-ground biomass and DBH. The conclusions from Rajput *et al*. (2017) were consistent with the result of this research.

Generally, the younger trees have been found to have a faster growth when compared with tree species that are older. Thomas (1996) was suggestive of the fact that tree species that grows rapidly are supposed to have high rate of development and may inadvertently amass significant quantities of carbon in the primary phase of their lifetime, slower-growing trees, on the other hand, have a higher specific gravity, which allows them to store more carbon over time. This uneven contribution of species to the tropical area's carbon stored might be owned to differences in species diversity, maturity, and mass. The mean carbon stock in above and below ground biomass of Gendo Forest was similar to those reported from Menagasha Suba State Forest when compared to previous research (Mesfin, 2011). As a result, it's plausible to argue that more protected savannah might aid in increasing the pace at which carbon is stored in the ecosystem. Finding from this study is in line with Grace *et al.* (2006) that found carbon sequestration rate (net ecosystem productivity) in tropical savanna ecosystems ranging from 1 to 12 t C ha/1/year. The study of Jibrin *et al*. (2014) in Kpashimi Forest reserve in Niger state, also corroborates the finding of carbon stock in Old Oyo National Park. Furthermore, the carbon storage is consistent with the findings of Agbelade and Onyekwelu (2020) in Ilorin urban forest which recorded 7.82 tons/ha but negates the findings of Adekunle *et al*., 2014 in Eda protected forest with 156.73 tons/ha. This is evident that protected areas in savanna ecosystem also contribute to greenhouse gas emission reduction. The level of variability of carbon sequestration exists within differing ecosystems. The variations in the amount of carbon stored may not be dependent only on anthropogenic disturbance, species diversity, climatic condition, but could be attributable to ecosystem type and model used in biomass sampling (Agbelade and Onyekwelu, 2020). Findings from this study also conforms with previous research (Campbell *et al*., 2008) which indicates that protected areas do not eliminate carbon stock change within them but rather promotes and contributes to global carbon sequestration.

5.6 Soil nutrient content at the Marguba Range of OONP, Nigeria

Soils act as both determinants and responders to changes in vegetation. The uptake and availability of nutrient and species diversity is influenced by soil pH. Andrew *et al*. (2002) reported that Aluminium, Manganese, and Iron are easily accessible to plants at pH <4.5 while Calcium, Potassium are available at high pH scale (>5.5). They recorded plants grow best in soils with pH value between 5.8 to 7.0. This corroborates the values recorded in this study (6.59-6.64) which showed the soils are slightly acidic and thus the plants had favourable growth circumstances as the soils indicate potential bioavailability of the macro and micronutrients. The acidity corroborates most sub-saharan West African alfisol soil. The soil nutrient regime in the buffer and core zone were relatively high. This can be attributed to high density of species belonging to the nitrogen-fixing family Fabaceae. The higher soil nutrient contents can also be attributed to the higher vegetation coverage with an improvement in the soil's organic material content of natural forests due to higher input of plant litters. Sawadogo *et al*. (2009) reported that in comparison to heavily grazed sites, ungrazed or lightly grazed forests showed an increase in soil organic carbon, this could be attributed to increment in plant litter above ground, which helps the soil to accumulate and form organic materials (Han *et al*., 2008).

Organic matter in the soil and carbon are used to determine the nutrient richness of the soil because they increase soil fertility, available moisture, and overall soil development (Edori and Iyama, 2017). The mean soil organic carbon contents of the study locations ranged from 1.57 to 1.72% while soil organic matter ranged from 2.80 to 2.94%. The most closely connected soil characteristics to floristic composition includes nitrogen, clay, organic matter, and sand, whilst aluminium is connected to richness of species (Silva and Batalha, 2008). Soils with nitrogen content greater than 0.1% was reported by Lamb *et al*. (2014) as being very good. The mean total nitrogen composition of the studied locations extended from 0.09 to 0.25%. Soils with high nitrogen content generally promotes the re-sprouting vigour in many species (Lamb *et al*., 2014) which compared to this study encouraged re-sprouters in the seed bank of the soil, along with vegetation composition.

Large number of family Fabaceae were encountered in this study, they are favoured because of their ability to regenerate after a fire and forms a significant source for the availability of nitrogen (Casals *et al*., 2005). They further change the relationship that exists with plants and soil resources, thus, encouraging plant growth. When nitrogen breaks down, it becomes available for plants to take up as inorganic nitrogen (Lamb *et al*., 2014). The total organic carbon (TOC) content of the soil is a sensitive indication of soil quality (Tefera *et al*., 2007) as it shows as soil fertility indicator and according to Djomo *et al*. (2016), It provides information on changes in soil fertility in addition to the long-term viability of Land use and management strategies. This is evident in the triplot analysis which showed a strong relationship between the species encountered and the soil physico-chemical components.

Although, the mean values obtained for Calcium (0.73 Cmol/kg – 0.89 Cmol/kg) and Potassium (0.01 Cmol/kg – 0.02 Cmol/kg) were quite low from buffer to core zone. This depicts the presence of ecological disturbance in the study locations especially at the core zone which recorded high influx of anthropogenic activities which corroborates the findings of Olatunji *et al*. (2015) that human activities disrupt soil activities leading to poor soil. This has also been reported for most soils in Nigeria (Uzoho *et al.,* 2007). Potassium and calcium are considered as the most abundant exchangeable bases in the soil (Middha *et al*., 2015); improves soil structure, water penetration thereby enhancing the environmental conditions for plant growth (Jain *et al*., 2015). Ojanuga and Awojuola (1981) classified soil cation exchange capacity (CEC) as low (<6 Cmol/kg), medium (6 - 12 Cmol/kg) and high (>12 Cmol/kg) for some Nigerian soils. Based on this classification, mean CEC of the studied locations ranged from 1.81 Cmol/kg for core zone to 1.91 Cmol/kg for buffer, which showed it was within the low class.

Phosphorus content ranging from 19.93 to 58.37 PPM were observed from buffer to core zones. Sawadogo *et al.* (2009) highlighted that the availability of phosphate and soil nitrogen concentrations were much higher in extensively grazed fields which corroborates the findings of this study as phosphorus content was observed to be higher in core than buffer zone which recorded relatively low phosphorus contents. Organic debris in the soil and plant disintegration may have contributed to the high level of phosphorus. This is similar to the study of Chrs-Emenyonu *et al*. (2020) who reported that high phosphorus content is implicated for high carbon content and vice-versa.

The soil samples textural class ranged from Sandy loam (SL) for Core zone to Loamy sand (LS) for the Buffer zone. This shows there was heterogeneity and has been posited by Oshunsanya (2013) to be typical of tropical soils. The physicochemical parameters obtained in the soil sampled across the location showed there was significance difference ($P<0.05$) except for potassium (K) that had no significance difference across the locations. The physicochemical properties of soil, such as textural class, pH, P, OC, ON affects the presence or absence of certain plant species and are therefore, important for plant vigour.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusions

To enhance conservation, it is important that we understand the local dwellers and indigenous people close to these resources for the benefit of proper monitoring of the functions and services they render to the ecosystem, by so doing, they understand their stake and are ready to cooperate with its management for their own benefit. The study also explored the effect of soil physicochemical properties and seasonality on the density and composition of above ground species and the soil seed bank. The Biomass and Carbon sequestration potential of the standing vegetation of the Core and Buffer zone were estimated through a non-destructive sampling method.

The following conclusions were deducted from the study:

1. The perception of respondents is favourable as they are aware of changes in their environment and are ready to conserve available resources.

2. There was low awareness of where the Park boundary with the unprotected area was demarcated (the demarcating signpost was destroyed), giving intruders the excuse of no clear demarcations of the buffer zone from the core zone.

3. The source of energy for the local dwellers was the fuelwood (Charcoal and firewood), with firewood having the highest usage potential.

4. The maintenance of biodiversity in National Parks is also dependent on the social relationships between local communities and Park workers.

5. The study highlighted the employment of Remote Sensing (RS) and Geographical Information System (GIS) techniques for natural resource management providing details on the kind of eco-region this study was carried out in.

6. The capacity of remote sensing and GIS to measure changes in environmental resource through time was demonstrated by changes in the landscape

composition and structure of the studied area, as indicated by variability (across time periods) in the metrics.

7. Bushfires, invasive species, and indiscriminate grazing are the major threats to herbaceous and woody species diversity. Human pressure was identified in the core zone from the landmarks and hunters' camps located in OONP.

8. The assessments revealed that the characteristics of the vegetation in the Marguba Range of Old Oyo National Park were generally similar to those of the guinea savanna areas.

9. It also showed that species composition and structure followed trends in the eco-region with dominance of typical guinea savanna region tree species

10. The families with the highest number of species in the herbaceous communities were Poaceae, Asteraceae, Fabaceae, Euphorbiaceae and Cyperaceae while the dominant families for woody species were Fabaceae, Combretaceae, Malvaceae, Meliaceae and Rubiaceae in the study area.

11. The description of species composition, structure and diversity of different plant communities confirms the principles of habitat heterogeneity in herbaceous composition and tree species in savannah vegetation.

12. The ecologically dominant herbaceous species in descending order were *Chromolaena odorata*, *Hyparrhenia involucrata*, *Aspilia bussei* and *Imperata cylindrica* while ecologically dominant woody species in descending order were *Lophira lanceolata*, *Piliostigma thonningii*, *Anogeissus leiocarpus*, and *Nauclea latifolia*.

13. The importance of soil seed bank for the recovery of a vegetation cannot be overemphasised as they form the history of native species in an ecosystem. Therefore, defining the optimal conditions for seed development is essential for the determination of their resilience to future impacts. The seed bank profiled some of the above-ground vegetation species; nevertheless, based on the species inventoried, there was little overlap (low similarity) between the seed bank and the above-ground vegetation.

14. The study provides a scientific contribution for accurate estimation of biomass and carbon stock in typical derived guinea savanna ecological area of Oyo state Nigeria. Future estimates can be compared as this study sets a baseline for calculating carbon stock in the Marguba Range of Old Oyo National Park.

15. Woody species that contributes most to the above ground biomass stock in the study area were *Piliostigma thonningii*, *Daniella oliveri*, and *Nauclea latifolia*, findings from the study implies *Piliostigma thonningii* is the woody species with highest potential to store atmospheric carbon as they had a high population density in this study.

16. The total carbon stock in the buffer and core zone was high (3.41– 7.53 t C/ha) and hence, its potential for carbondioxide absorption from the atmosphere is high in the woody species population. The implication is that more woody species are in the core zone and will contribute to carbon sequestration potential of the National Park.

17. Findings from this study revealed that the three most important set of predictors of biomass/carbon stock in the study area, were tree density, DBH and basal area.

6.2 Recommendations

The following recommendations should be considered based on the findings of this study

1. Locals should be more engaged in the management of the park; this way they are saddled with responsibility of the park which further strengthens its management, and conflicts are avoided. Appropriate signs and warning posts should be mounted at strategic places in the park.

2. Ensure the local communities' economic and social sustainability is met. This may be accomplished by developing alternate sources of income, providing alternate energy sources, and establishing public facilities.

3. From the scope of this study, it is necessary that farmers and local dwellers should be properly enlightened and educated towards conservation of the native diversity and the consequences of their activities on the ecosystem of the park. Conservation effectiveness and education needs to be strengthened and

intensified in communities around protected areas and maximising the advantage of youth population.

4. When researching the effectiveness of a park, it is expedient that social aspect as it relates to local dwellers, and remote sensing should be used for effective conclusion to be deduced about the drivers of change (success and failure). Involving the local communities in the process may be highly beneficial in forest conservation. Therefore, conservation strategies to protect the diversities (fauna and flora) against anthropogenic activities should be put in place to increase the abundance of species. Invasive species should be controlled in the park for the native species to thrive and for easy feeding of the wildlife by controlling the influx of herdsmen and their herds of cattle, and effective monitoring for early detection of new or introduced plant species.
5. It is vital to provide park workers with training in community social connections and development, as well as scientific management of flora and fauna species and their environments. As a result, management measures for restoring the Park as a fully functional, long-term ecosystem should be devised.
6. Proper monitoring of the Park's ecosystem is imminent, and this should be further enhanced with the help of Geographical Information System (GIS) to be in the know of the health and status of the park. This will help determine where more greenness is needed, and tree planting can be incorporated to fill up the open spaces for thicker vegetation which will enhance forest cover and boost the influx of wildlife as their habitat is restored.
7. Regular vegetation structure and composition monitoring in all areas around protected areas, with ecological monitoring efforts not restricted within protected area boundaries. To comprehend the sociocultural concerns surrounding the survival of woody plant species in unprotected areas dominated by human activities, it is necessary to tap into local ecological knowledge.

8. It is pertinent to understand the extent and rate at which (PAs) are affected by land use change. The degree to which improving effectiveness of existing PAs could make an effective contribution to reducing emissions from deforestation and forest degradation. Global commitments need to be strengthened to effectively defend Protected Areas capacity in a path to social, economic, and environmental objectives.

9. The importance of soil seed bank for the recovery of vegetation cannot be overemphasised as they form the history of native species in an ecosystem, therefore, defining the best germination condition is important to figure out their resilience to future impacts. This study recommends a regular soil seed bank assessment to establish resilience and persistence of the native species.

6.3 Contributions to knowledge

The present study revealed that:

1. Species composition in the Buffer and Core zones of the Marguba Range was established. The Buffer zone was more degraded compared to the Core zone.
2. Seasons of the year determined species composition, standing vegetation and soil seed bank.
3. There was high potential for the regeneration of herbaceous species but low potential for woody species to regenerate in the Marguba range of Old Oyo National Park, Oyo State, Nigeria.
4. Activities of herdsmen and landscape degradation encouraged the presence of notorious invasive species such as *Chromolaena odorata*, *Hyparrhenia involucrata* and *Aspilia bussei* in the Buffer and Core zones.
5. Presence of *Aspilia bussei*, a pioneer species, indicates disturbance and degradation of the study area.
6. Change in ecological functions of the Marguba Range of the Old Oyo National Park was occasioned by change in land use and land cover systems.

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APPENDICES

Appendix 1: Questionnaire

This questionnaire is primarily documented for the collection of data on changes in usage and cover of the land, impacts and ecological implications for the management of the **Marguba Range of Old Oyo National Park**. Data generated from this questionnaire will be helpful in the provision of documents that will inform policy - makers and funding agencies should be aware of the rate and patterns of changes in land cover and usage, as well as their impact on biodiversity. As a stakeholder, your inputs in provision of information in this questionnaire is highly appreciated. There is a confidentiality oath on the provided information and your decision to participate or not to participate is honored.

Section I - Background information in general

1. Age (in years) **……..**

2. Gender **……….**

3. Size of household **……….**

4. Village/Town **……………………………..**

5. Educational Status a. Primary education {} b. Secondary education {} c. Tertiary education {}

6. Source of income a. Civil servant {} b. Teacher {} c. Farmer {} d. Trader {} e. Artisan {}

7. Total farmland owned**……………….** (ha) Distance from household **……………….**

8. Proximity to the park (km/m) **………………………………………….**

9. Has your farmland extended in recent years? a. Yes {} b. No {}

10. Is the expansion towards the park? a. Yes {} b. No {}

Section II-Soil and Water related issues

1. Do you have access to good water in your locality? Yes/No
2. Indicate your Source of water among the following **……**

a. Stream/Water []

b. Lake []

c. Rain []

d. Well []

e. Borehole []

3. What farming system do you use? 1. Crop rotation {} 2. Fallow system {} 3. Shifting cultivation {} 4. Agroforestry {} 5. Taungya system {}

Activities observed in the park

4. Which of the following activities do you observe going on in the park? 1. Farming [] 2. Deforestation [] 3. Charcoal production [] 4. Bush burning [] 5. Poaching [] 6. CGP (Charcoal production, Bush burning and Poaching) [] 7. BP (Bush burning and Poaching) []

Sources of Energy

5. What source of energy/fuel do you use? 1. Kerosene {} 2. Gas {} 3. Firewood {} 4. Charcoal {} 5. others (specify) **…………………………….**

Section III—Availability of vegetation and dynamics

6. Identify and provide the significant woody/shrubby species present in your neighbourhood and indicate its major purpose for use as in footnote:

Vernacular names of trees	Firewood		Charcoal	
	Harvested	Not harvested	Harvested	Not harvested

Indicate the specific trees harvested if you use firewood or charcoal

7. Do wild animals come to your community? Yes/No

8. Indicate the wild animals you see in and around your community

a. Wild-dog []

b. Warthogs []

c. Baboon []

d. Monkeys []

e. Kobs []

f. Antelope []
g. Wild-lizard []
h. Duiker []
i. Others

……………………………………………………………………………

Knowledge of environmental problems

9. Are you aware of environmental problems in your locality? a. Yes {} b. No {}

If yes, please indicate your awareness of the following environmental problems;

Environmental problems	Aware	Unaware
Vegetation and soil fertility degradation		
Soil erosion		
Water contamination		
Bush burning		
Illegal farming		
Massive deforestation		
Poaching		

10. Below are some statements about farmer's knowledge of environmental problems and park accessibility. Please indicate whether you Strongly Agree (A), Undecided (U) and Disagree (D) with the statements as follows:

S/N	Statements	SA	U	D
1	Water is highly accessible, the quality and quantity available is in the right proportion.			
2	Land degradation and Drought are prominent factors/problems in your locality			
3	There has been pre-existing risk of crisis or destruction to the park and its environs.			
4	Humans are always allowed into the park for resource extraction			
5	Frequent bush burning results in destruction of living organisms in the soil thus reducing the productivity of the soil and income of farmers.			
6	Massive deforestation results in destruction of soil and loss of its fertility, which will ultimately affect farmer's income.			
7	Fertility of land is better managed by alternating crops of different root depth on same piece of land in rotation and bush fallow system.			
8	Farmers could improve land fertility better by applying organic manure rather than fertilizer.			

9	Water quality would be better enhanced if farmers discourage and where necessary report, community member that pollute water to the appropriate government authorities.			
10	Farmers can enhance soil productivity if they minimize ploughing and ridging.			
11	Planting the same crop on a piece of land has no effect on land productivity.			
12	The Park is beneficial to you through resource extraction.			
13	The government takes care of the community through development of social amenities and provision of necessary incentives.			
14	Poaching is strongly allowed in the park and its environs.			
15	The cropping system I employ promotes good soil fertility and management.			
16	There's availability of farmland for agricultural purposes in the park.			
17	Loss of land cover is detrimental to proper functioning of the park			
18	Climate change mitigation is supported by land cover			
19	The effectiveness of the park can be reduced by Climate change			
20	Climate change can be mitigated through Afforestation and effective use of land for soil carbon sequestration.			
21	Buffer zones are designed to buffer the conservation area from depredation of the community.			
22	Locals are allowed into the buffer zone of the park for resource extraction.			
23	There are buffering effect from the damage on crops by wild animals for farmlands close to the or in the buffer zone			
24	Wildfires are detrimental to farmlands in the buffer zones.			

Perception of the Park's management

11. What is your perception of the relationship you have with park officials?
12. Do you think conflict exists between the management of the park and local dwellers surrounding the park? What is your perception of it?
13. Can you elaborate on what you think the sources of conflicts are?
14. Is there any educational, enlightenment, or advocacy provided by the park's management to the surrounding communities?

Special remarks of the interviewer/ remarks made by the person who was interviewed on the provided information:

…………………………………………………………………………

Plate 1: Hunters camp in the Marguba range of Old Oyo National Park, sighted in 2019.

Plate 2: **The vegetation of Marguba range of Old Oyo National Park in wet season (A and B) showing the invasiveness of Chromolaena odorata in plate A.**

Plate 3: The vegetation of Marguba range of Old Oyo National Park in dry season

Appendix 2: Global Positioning System location, elevation and Real-time Weather data of the Marguba range of Old Oyo National Park 2017-2019

Location	Latitude	Longitude	Elevation	First year					Second year				
				Temp	Dewpoint	RH	WSM	WSmin	Temp	Dewpoint	RH	WSM	WSmin
BF 1	8.51754	3.72984	318	80.6	86.9	79.9	0	0	69.1	68.4	53	1	0.6
BF 2	8.51824	3.73016	316	79.3	88	89.9	1.2	0	70.5	69.8	49	1	0.8
BF 3	8.51897	3.73031	314	79.8	81.9	91.9	1.2	0	75.8	75.4	41	1.4	1
BF 4	8.51966	3.7307	313	79.3	86.5	87.5	1	0	76.1	74	36	1.7	1.1
BF 5	8.52043	3.73078	314	83.1	93.1	83	1	0	76.8	76.3	39	2.9	1.1
BF 6	8.52117	3.73101	312	79.6	90	83.8	0	0	80.7	80.1	33	1.6	0.9
BF 7	8.51713	3.72969	331	85.6	100.5	81.9	0	0	84.2	82	30	1.7	1.3
BF 8	8.51645	3.73008	331	84.8	102.2	96.5	1.1	0	85.6	83.8	29	2.3	1.1
BF 9	8.51589	3.73066	329	83.5	103.5	82.1	1.2	0	85.6	84.1	26	2.1	1.1
BF 10	8.5153	3.73113	329	85.1	98.2	79.8	1.1	0.2	87.2	83.5	26	1.2	1.1
BF 11	8.51489	3.73177	327	89.2	100.1	82.4	1.2	0	88.6	87.4	25	1.6	1.4
BF 12	8.51438	3.73236	332	85.9	89.5	83.2	1	0	86.9	85.1	25	1.5	1
AJ 1	8.49668	3.74082	339	84	98.6	85.1	0	0	93.4	91.4	22	0	0
AJ 2	8.49734	3.74116	335	87.3	117	89.6	0.8	0	98.1	95	19	1.1	0
AJ 3	8.49738	3.74135	334	87.2	107.8	88.8	0	0	93.6	90.7	19	1.2	0.8
AJ 4	8.49779	3.74189	332	88.2	120.1	92.5	0	0	92.2	91.1	21	0	0
AJ 5	8.49816	3.74248	332	89.6	105.4	77.3	1.5	0.6	95.4	97.6	32	0	0
AJ 6	8.49879	3.74286	329	87.7	106.9	84.3	1.2	0.7	96.4	98	32	0.6	0
AJ 7	8.50444	3.74527	316	83.3	96.7	87.7	0.7	0.6	93.2	92.7	28	0	0
AJ 8	8.50372	3.74541	314	83.6	98.4	87	1.6	0	92.1	90.9	24	0	0
AJ 9	8.50297	3.74563	314	86.5	103.1	81.9	1.6	0	92.9	91.4	22	0.8	0
AJ 10	8.50222	3.74554	313	85.8	101.9	80.9	1.6	0	93.1	92.1	25	0	0
AJ 11	8.50156	3.74512	314	86.1	108.3	85.1	0	0	92.9	90.7	25	0	0

AJ 12	8.50122	3.74437	315	86.2	101.7	84.1	0.9	0	93.3	92.4	24	1.2	0.7
IB 1	8.45676	3.77178	296	89.9	106.3	76.3	1.4	0	73.8	72	38	0	0
IB 2	8.45721	3.77258	317	87.7	105.9	83.4	1.2	0.9	81.3	79.7	33	1.2	0
IB 3	8.45749	3.7731	316	85.1	109.5	81.5	1.7	0.6	82.6	82.4	26	2.8	0.6
IB 4	8.45802	3.77369	314	85.6	100	84.1	1.1	0.6	84.4	81.6	22	3.3	0.6
IB 5	8.45819	3.77453	310	89.1	103.7	82.4	1.2	0.7	83.9	81.4	21	3.3	0.6
IB 6	8.45862	3.77504	308	87.3	101.3	81.9	1.3	0.6	85.1	83.4	24	4.1	0.6
IB 7	8.45662	3.77151	318	89.9	112.2	78.9	1.4	0	90.7	91.4	32	4.1	0.6
IB 8	8.45622	3.77086	317	89.6	114.2	81	0	0	91.4	88.9	20	4.1	0.6
IB 9	8.45577	3.77023	315	89.8	110.7	80.6	1	0	88.3	89.4	31	4.4	2.9
IB 10	8.45514	3.76983	311	88.6	103.8	82.5	0.8	0	88.7	87.3	20	3	1.6
IB 11	8.45474	3.76978	308	88	117.4	98.9	1	0	90.6	89.5	25	1.2	0.7
IB 12	8.45464	3.7698	308	87.5	105.1	93.5	0.8	0	90.2	86	19	0.8	0

BZ – Buffer zone, IB – Ibuya, AJ – Ajaku, RH – Relative Humidity, WSM –Maximum Windspeed, Temp. – Temperature, WSmin –Minimum Windspee

Appendix 3: Human and Animal activities observed during survey in the Buffer and Core zones of the Marguba range of Old Oyo National Park in 2017-2019

Variable	Coordinate		
	Latitude	Longitude	Elevation
Sterculia setigera	8.31054	3.438	310
Farmland	8.31223	3.43798	313
Farmland with Yam heaps	8.51645	3.73008	331
Farmland with Yam heaps	8.51589	3.73066	329
Farmland with Yam heaps	8.5153	3.73113	329
Orabia oribi track (like duiker)	8.29984	3.44554	342
Kobs track	8.30034	3.44601	322
Kobs track	8.29969	3.44836	318
Rabbit hole/Ground squirrel	8.29979	3.44727	318
Fulani way point	8.31006	3.43759	318
Invasive *Chromolaena*, maybe fallow	8.30979	3.43734	315
Gunshots in the buffer zone (bird feathers)	8.31088	3.43802	312
Human track	8.31182	3.43884	309
Duiker trail	8.27399	3.46301	293
Kobs trail	8.27376	3.46115	297
Kobs trail	8.2737	3.4622	304
Human trail	8.27401	3.46301	308
Cochlospermum land /Blackneck dove/Red patas monkey/rocky outcrop	8.27438	3.46393	310
Kobs trail	8.27499	3.46477	308
Poacher’s camp	8.27537	3.46538	308
Poacher’s camp	8.27639	3.46687	308