CARBON STOCKSAND SEQUESTRATION POTENTIAL OF IBODI MONKEY FOREST IBODI, ATAKUMOSA WEST LOCAL GOVERNMENT AREA OF OSUN STATE, NIGERIA

BY

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ABSTRACT

Ibodi Monkey Forest (IMF) is known for its illegal mining activities, which have led to the degradation of the forest ecosystem. Most studies on the forest focused on floristic and monkey species diversity. The Carbon Stock (CS) and Sequestration Potential (SP), which are critical for mitigating CO_2 emissions of IMF, have not been fully quantified. This study therefore investigated the distribution pattern of Carbon pools and Sequestration potential in different physiognomies in the forest.

Four plots of 25 m × 25 m each were randomly selected in three physiognomies: Regrowth Forest (RF), Cocoa Plantation (CP) and Tree Fallow (TF). In each physiognomy, all standing trees with Diameter at Breast Height ≥10cm were identified, measured and enumerated. Mean Basal Area (MBA) of the plants was determined using standard formulae. The biodiversity indices derived included Shannon-Wiener Diversity Index (SWDI), Sorenson's Similarity Index (SSI) and Family Importance Value Index (FIVI). The temporal changes in the study site were determined by comparing results with baseline data. A diagonal transect was laid within each plot for soil sample collection at four soil depths (0-15, 16-30, 31-45, and 46-60 cm). Biomass and CS in different carbon pools, namely Soil Organic Carbon (SOC), Above Ground Carbon (AGC), Below Ground Carbon (BGC), Herb-Litter-Saplings (HLS) were calculated using standard methods. Carbon Sequestration Potential (CSP) was determined from the soil and plant litter analyses as well as allometric equations using standard formulae. Data were analysed using descriptive statistics and ANOVA ($\alpha_{0.05}$).

Eighty-seven, eighty-six and one hundred and six plant species were encountered in the RF, CP and TF, respectively. The estimated MBA (m_2ha^{-1}) were 17.96, 13.12 and 1.93 for RF, CP and TF, respectively. The SWDI in the three physiognomies was 3.02, 0.39 and 0.29 for RF, CP and TF, respectively. The SSI in all the physiognomies studied showed low similarities with CP and TF being the most similar (48.9%), while RF and CP were most dissimilar (35.1%). Family Sterculiaceae (60.65) had the highest and Polygalaceae (1.43) had the lowest FIVI. There were significant differences in the number of species when compared to baseline data. Total SOC (tha^{-1}) in the three physiognomies was 333.11, with 144.34 (RF), 94.37 (CP) and 94.40 (TF). Total AGC ($tCha^{-1}$) stock was 5492.93, the trend was 3529.29 (RF) > 1477.12 (CP) > 486.52 (TF). Total BGC ($tCha^{-1}$) stock was 823.94, in the order 529.39 (RF) > 221.57 (CP) > 72.98 (TF). Total HLS CS ($tCha^{-1}$) was 0.15 with the trend 0.09 (RF) > 0.04 (CP)> 0.02 (TF). The total CSP (tCO_2eha^{-1}) in IMF was 24386.02. The pool trend was 20142.57 (AGC) > 3021.39

(BGC) > 1221.51 (SOC) > 0.55 (HLS). There were significantly higher CS and SP values in RF compared to CP and TP across different Carbon pools due to the presence of more woody species in the physiognomy.

Ibodi Monkey Forest has an appreciable carbon storage potential, with the regrowth forest being best in carbon storage. Increased anthropogenic activities at the fringes of the forest should however be controlled.

Keywords: Biodiversity, Plant biomass, Cocoa plantation, Forest regrowth, Tree fallow

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CERTIFICATION

This is to certify that this research study was carried out by Emmanuel Timilehin KOMOLAFE (Matric No. 196564), under our supervision as part of the requirements for the award of Doctor of Philosophy (Ph. D.) in the Department of Botany, Faculty of Science, University of Ibadan

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(Co-Supervisor)	

DEDICATION

This work is dedicated to God almighty the giver, and ultimate source of wisdom, through His finger this became a reality, to Him alone be all the praise. (Amen)

TABLE OF CONTENTS

Title page	I
Abstract	II
Acknowledgements	III
Certification	V
Dedication	VI
Table of content	VII
List of tables	XI
List of figures	XIV
CHAPTER ONE: **INTRODUCTION**	
1.0 Introduction	1
1.1 Justification of study	3
1.2 The Objectives of the study	4
CHAPTER TWO: **LITERATURE REVIEW**	
2.1 Biodiversity in tropical forest and Climate Change	5
2.2 Deforestation and Degradation of forest	6
2.3 The concept of climate change	9
2.4 Causes of Climate change	10
2.5 Greenhouse gases	11
2.6 Roles of forest in climate change	13
2.7 The cycling of carbon in the forest	13
2.8 Carbon Pools and Sequestration	14
2.9 Biomass Estimation	17
CHAPTER THREE: **MATERIALS AND METHODS**	
3.1 Study area	18
3.1.1 Location Topography, Drainage, and Soils of the study area 18	
3.1.2 Climate and vegetation of the study area	18
3.2 Selection of plots	19

3.3 Method of Data Collection 22
3.3.1 Tree Species Identification 22
3.3.2 Basal Area Estimation 22
3.3.3 Tree Species Classification and Biodiversity Indices 23
3.4 Biomass and Carbon Stock Estimation 26
3.4.1 Estimation of Aboveground biomass of Woody Species 26
3.4.2 Species Height Measurement 26
3.4.3 Determination of Specific wood gravity 26
3.4.3 Selection of Allometric Equation 27
3.4.4 Carbon stock estimation in aboveground pool 28
3.4.5 Evaluation of Belowground Biomass 28
3.5 Assessment of Biomass in the aboveground and carbon storage in the understory in all the three physiognomies 28
3.6 Standing Floor Litter Collection 29
3.7 Soil carbon stock estimation 30
3.8 Estimation of Carbon sink (sequestration) potential of Ibodi monkey forest 30
3.9 Statistical Analysis 30
CHAPTER FOUR: **RESULTS**
4.1 Floristic Pattern and composition of the study area 32
4.1.1 Composition of Species encountered 32
4.1.2 Woody species 46
4.1.3 Herbaceous species 51
4.1.4 Climbers, Epiphytes, ferns and Grass species 54
4.2 Temporal changes in the floristic composition of Ibodi monkey forest 57
4.2.1 Temporal changes Summary of Species encountered in 2013 and now 57
4.2.2 Temporal changes in Woody species 59
4.2.3 Temporal changes in herbaceous species 59
4.2.4 Temporal changes in Climbers, Epiphytes, ferns and Grass species 60

4.3 Vegetation Structure 63
4.3.1 Tree Species Classification and Biodiversity Indices 63
4.3.2 Woody species density 67
4.3.3 Basal Area distribution 70
4.3.4 Family Important Value Index (FIVI) 73
4.4 Temporal changes in the forest structure of Ibodi monkey forest 75
4.4.1 Temporal changes in the tree Species Classification and Biodiversity Indices 75
4.4.2 Temporal changes in woody species density 79
4.4.3 Temporal changes in the basal area 81
4.5 Carbon stock in the three physiognomies of Ibodi Monkey forest 84
4.5.1 Soil organic carbon Nitrogen (N), Organic matter (OM) in the three physiognomies of Ibodi Monkey forest 84
4.5.2 Soil Carbon Stocks in three physiognomies in Ibodi Monkey forest 90
4.5.3 Aboveground and carbon stock in Ibodi Monkey forest 92
4.5.3.1 The Selection of Allometric Equation 92
4.5.3.2 Aboveground biomass of woody species in the three physiognomies 94
4.5.3.3 Carbon stock estimate in aboveground pool in Ibodi monkey forest 100
4.5.4 Belowground biomass and carbon stock 105
4.5.5 Litter, saplings and herbaceous species Organic carbon (OC), Nitrogen (N), Organic matter (OM) in the three physiognomies of Ibodi Monkey forest 110
4.6 Summary of all carbon stock in Aboveground, below ground, soil, litter, herbs, sapling and sequestration potential of Ibodi Monkey forest 114
CHAPTER FIVE: **DISCUSSION**
5.1 Floristic composition of Ibodi monkey forest 117
5.2 Vegetation structure of Ibodi monkey forest 119
5.2.1 Species richness, diversity, and evenness among the three physiognomies 1119

5.2.2 Sorensen index of similarity among the three physiognomies 119
5.2.3 Woody species density 119
5.2.4 Basal Area distribution 120
5.2.5 Family Important Value Index 121
5.3 Temporal changes in the floristic composition and structure of Ibodi Monkey forest 121
5.3.1 Temporal changes floristic composition and structure of Ibodi Monkey forest 121
5.3.2 Temporal changes in the forest structure of Ibodi Monkey forest 123
5.3.2.1 Temporal changes in the tree Species Classification and Biodiversity Indices 123
5.3.2.2 Temporal changes in woody species density 124
5.3.2.3 Temporal changes in the basal area 124
5.4 Carbon stock and sequestration potential in Ibodi Monkey forest 124
5.4.1 Soil organic carbon (SOC), Nitrogen (N), Organic matter (OM) in Ibodi Monkey forest 124
5.4.2 Soil Carbon Stocks in Ibodi monkey forest 126
5.4.3 Aboveground Biomass and Carbon stock in the aboveground pool 126
5.4.4 Carbon stock in the herbs, shrubs and litter pool 127
5.5 Carbon sequestration potential 128
CHAPTER SIX: **SUMMARY AND CONCLUSION**
6.1 Summary 129
6.2 Conclusion 129
6.3 Recommendation 130
6.4 Contribution to Knowledge 130
6.5 Suggestion for further Studies 130
REFERENCES 131
APPENDIX
Appendix 1.1 151
Appendix 1.2 156

Appendix 1.3 161

LIST OF TABLES

Table		Page
3.1	Geographical location of each plot at Ibodi Monkey Forest	20
4.1	Plant species encountered in the Regrowth forest physiognomy of Ibodi monkey forest, Ibodi, Osun State	33
4.2	Plant species encountered in the Cocoa plantation physiognomy of Ibodi monkey forest, Ibodi, Osun State	36
4.3	Plant species encountered in the Tree fallow physiognomy of Ibodi Monkey forest, Ibodi, Osun State	40
4.4	Woody Species encountered in the three physiognomies of the monkey forest Ibodi, Osun State	47
4.5	Herbaceous Species encountered in the three physiognomies of the monkey forest Ibodi, Osun State	52
4.6	Climbers, Epiphytic, Fern and Grass Species encountered in the three physiognomies of the monkey forest Ibodi, Osun State	55
4.7	Margalef, Shannon-Wiener and Evenness Indices in the three Physiognomies of the study area	64
4.8	Sorensen's index (%) of similarity of the three Physiognomies of the study area	66
4.9	Mean Density of woody species (per Hectare) in the three physiognomies in the study area	68
4.10	Mean basal area of woody species (m^2 per hectare) in the three physiognomies in Ibodi Monkey forest, Ibodi, Osun State	71
4.11	Family Importance Value Index (FIVI) of all families in the physiognomies in Ibodi Monkey forest, Ibodi, Osun State	74
4.12	Temporal change in the tree species classification and biodiversity indices the physiognomies in Ibodi Monkey forest, Ibodi, Osun State	76
4.13	Temporal changes in Sorensen's index (%) of similarity of the three	

Physiognomies of the study area 78
4.14 Temporal change in the woody species density per hectare the physiognomies in Ibodi Monkey forest, Ibodi, Osun State 80
4.15 Temporal change in basal area (per hectare) of woody species in the three physiognomies in Ibodi Monkey forest, Ibodi, Osun State 82
4.16 Summary of temporal changes in floristic composition and Structural characteristics of the three physiognomies in Ibodi monkey forest 83
4.17 Soil organic carbon, Organic matter an Nitrogen content in all three physiognomies in Ibodi Monkey forest 86
4.18 Soil carbon stock ($t.ha^{-1}$) in the three physiognomies in Ibodi monkey 91
4.19 Multiple regression analysis of different allometric equations in estimating the aboveground biomass (AGB) in the three physiognomies in Ibodi monkey forest 93
4.20 Aboveground biomass of woody species in the regrowth forest physiognomy 95
4.21 Aboveground biomass of woody species in the Cocoa plantation physiognomy 98
4.22 Aboveground biomass of woody species in the Tree fallow physiognomy 99
4.23 Carbon stock estimate in aboveground pool in Regrowth forest physiognomy in Ibodi monkey forest 101
4.24 Carbon stock estimate in aboveground pool in Cocoa plantation physiognomy in Ibodi monkey forest 103
4.25 Carbon stock estimate in aboveground pool Tree fallow physiognomy in Ibodi monkey forest 104
4.26 Belowground biomass and carbon stock in the regrowth forest physiognomy 106
4.27 Belowground biomass and carbon stock in the Cocoa plantation physiognomy 108

4.28 Belowground biomass and carbon stock in the Tree Fallow physiognomy 109

4.29 Litter, saplings and herbaceous species organic carbon, Organic matter an Nitrogen content in all three physiognomies in Ibodi Monkey forest 111

4.30 Litter, saplings and herbaceous species Biomass and carbon stock in all three physiognomies in Ibodi Monkey forest 113

4.31 Sequestration potential of Ibodi Monkey forest 115

LIST OF FIGURES

FIGURE		PAGE
2.1	Global carbon pools	16
3.1	Map of Ibodi Monkey Forest Ibodi, Atakumosa West Local Government Area of Osun State, Nigeria	21
4.1	Plant family dominance of species in all the three physiognomies	45
4.2	Temporal changes Summary of Species in 2013 and 2017	58
4.3	Temporal changes in the different group of species in the study area	62
4.4	soil organic C concentrations (%) in the different sampled soil depth of the different physiognomies	87
4.5	Soil organic C concentrations (%) in the different sampled soil depth of the different physiognomies	88
4.6	soil organic matter concentrations (%) in the different sampled soil depth of the different physiognomies	89
4.7	Ibodi carbon sequestration potential in different pools ($t.CO_2e.ha^{-1}$)	116

CHAPTER ONE
INTRODUCTION

1.0 Introduction

Climate change due to increased concentrations of Carbon dioxide (CO_2) in the atmosphere is one of the most widely discussed contemporary issues. The atmospheric concentration of CO_2 was estimated at 415 ppm (NOAA, 2019), this figure is 54% above the preindustrial fig ure of 270 ppm (which had been stable for thousands of years), and almost twice as high as it was towards the end of the last ice age (Neftel *et al.*, 1988; IPCC, 2014).

The threat of global climate change has brought with it considerable attention to forests as viable option for mitigating CO_2 emissions through Carbon sequestration. In effect, forest s constitute an enormous repository of carbon (FAO, 2003; Mokany *et al.,* 2006). Forests a lone contain approximately 48% of terrestrial carbon (IPCC, 2001; Liu *et al.*, 2014), and a ccount for more than 50% of global amount of carbon fixed during photosynthesis by all p roducers in the ecosystem (Beer *et al.*, 2010; Pan *et al.*, 2011).

Estimating carbon sequestration potential of forests is an important exercise for comprehe nsive carbon inventory for different purposes, especially in proffering sustainable manage ment strategies. Tropical forests are the most diverse and important terrestrial ecosystem (T urner, 2001; Lewis *et al.,* 2015) which plays a significant role in the global carbon cycle (N go *et al.*, 2013). The world's tropical forests house 200–300 Petagram (Pg) of carbon, whi ch is about 54% of the biotic carbon pool (Baccini *et al.*, 2012; Avitabile *et al.*, 2016), and a bout 39% of the atmospheric carbon pool (Le Quéré *et al.*, 2016). Although tropical forests play a crucial role in the global carbon balance, data available on carbon sequestration in tro pical regions are either limited or incomplete (Le Quéré *et al.*, 2016). Thus an extensive quantification of carbon pools in tropical forest ecosystems is important for understanding their contribution to net carbon sequestration. There has been a considerable decrease in global forest cover between 1990 and 2015, from 4123 billion ha to 3999 billion ha (Keenan *et al.*, 2015; Han *et al.*, 2017). Deforestation rates have been particularly high in the tropical region. According to Hansen *et al.* (2013) about 100 million ha of tropical forests were converted to farmlands between 1980 and 2012, which amounts to approximately 0.4% per year.

In Nigeria, 55.7% of primary forest has been lost between 2000 and 2005 (FAO, 2016). Furthermore, it has been reported that every year, Nigeria cut down roughly 350,000-400,000 hectares of forest per year (NACGRAB/FDA, 2008; Adedeji *et al.*, 2015; Mukhtar, 2016). Most of these trees are used in contruction of roads, bridges, houses, and fuel for cooking. Also, foreign businessmen are taking advantage of lax regulatory law and enforcement environment, as well as corruption by government officials to drive illegal trade and export of the country's forestry resources that might have grave consequences on the environment and economy. The implications of these are already staggering; Nigeria has about 1400 recognised species of amphibians, birds, mammals, and reptiles as stated by the global Conservation Monitoring Centre. Endemic of these was 1.2%, and 3.5% are threatened, because logging and cutting down forest vegetation. More striking though which is of utmost importance is the fact that deforestation has greatly increased our temperature and reduced rainfall in Nigeria. Studies have shown that Nigeria has experienced temperature increase of 1.10℃ within a period of 105 years which is far greater than global average increase in temperature of 0.74℃ recorded since 1860 (Odjugo, 2010). The same study also reported that the quantity of rainfall has dwindles by 81mm. Trees that are supposed to absorb carbon dioxide are no more there since they have been cut down.

1.1 Justification of the study

This study has become an important exercise for comprehensive carbon inventory, especially in proffering sustainable forest management strategies which can be emplaced to arrest the impending ills of change in climate due to deforestation. Management initiatives like Reduced Emissions from Deforestation and forest Degradation and enhancing forest carbon stocks and Clean Development Mechanism are international framework to help stop deforestation and enhancing forest carbon stock are germane for reducing reliance on the natural forest, a core source of energy in developing world. Reduced Emissions from Deforestation and forest Degradation is a proven United Nations Initiative created to reduce emission from deforestation and forest degradation. It is working by creating financial value for the carbon stored in the forest through the sale of verified emission reductions units. Reduced Emissions from Deforestation and forest Degradation projects make forests more valuable. Furthermore, payment for environmental services and the potential for addressing climate change by reducing greenhouse gas emissions provide positive impacts on forest management, conservation of biodiversity and sustainable development of forestry resources (Milledge *et al.,* 2007). However, there is need for proper forest monitoring and regular comprehensive forest inventory evaluation.

Among the gazetted forest reserves in Southwest Nigeria, Ibodi Monkey Forest has unique biodiversity with existence of endemic Monkey species. However, this ecosys tem is highly prone to adverse environmental changes occasioned by anthropological interferences at the fringes of the forest which is exacerbated by poverty and many decades of sole dependence on farming by the local community in the area. Ibodi Monkey forest has been significantly altered by gradual extraction, and conversion for oth er purposes.

Measures are needed to arrest the ongoing destruction of Ibodi Monkey Forest (together with its biota) and the subsequent release of its carbon stocks. The purpose and choice of this current stu dy was to provide an understanding of the role Ibodi monkey forest can play in the mitigat ion of climate change through carbon sequestration. The result obtained from this forest will also enhance and expedite policy decisions of the president's signing of the Paris Agr eement on Climate Change which Nigeria demonstrated commitment towards reversing t he effects of the negative trend of global warming.

1.2 The Objectives of the study

The objectives of the study were to:

1. Estimate Carbon Stock and storage potential in the aboveground biomass across different physiognomies in the forest.
2. Estimate Carbon storage potential in both the soil pool and standing floor litters across the physiognomies in the forest
3. Compare the variation in carbon content between aboveground biomass, soil and standing floor litter across the different vegetation.
4. Determine temporal changes in aboveground species by comparing data that will be obtained with the baseline enumeration data taken in 2013

CHAPTER TWO

LITERATURE REVIEW

2.1 Biodiversity in the tropical forest and Climate Change

Tropical forests are natural type of forest that are prominent for rich biodiversity, food, and carbon storage. Tropical forests consist of 44% and the largest proportion of the world's forests (FAO, 2011). Reports shows that the tropical forest houses one of the largest pools of carbon and have a noteworthy role in the world's carbon cycle (FAO, 2011). Forests hold about 80% of total aboveground organic carbon and 40% of the belowground organic carbon globally (Gullison *et al.*, 2007).

Forests provide sites for monitoring trends of climatic changes both in terms of net carbon emissions and global storage capacities which are important for climatic regulation processes of nutrient uptake as forest ecosystem is highly influenced by changes in atmospheric CO_2 (Terakunpisut *et al.,* 2007). Record shows that about 50% the weight of dry wood is carbon and that carbon is stored (sequestered) as long as the wood exists (Ecolink, 2007). Furthermore, forests contain approximately 75 percent of the global biomass (Cloughesy, 2006). It has a huge ability to store carbon primarily by reforestation, agroforestry, and conservation of existing forest stand. They are most diverse, productive at the same time vulnerable to change (Sala *et al.,* 2000; Siche and Ortega, 2008). Young quick growing forests sink carbon dioxide more quickly than old growth forests. Old growths are characterized by slow growing trees and loss of carbon owing to death and also the decay that may lead to carbon loss on the long run (Ecolink, 2007). Biomass of forest is a pointer to carbon sink, and it bears more role in efforts to mitigate climate change. The quantity of carbon sunk by a forest can be estimated from its biomass accumulation because about half of forest dry biomass is carbon (Brown, 1997). Majority of biomass quantifications are done for the aboveground biomass of trees. The reason is that this biomass generally signifies the greatest portion of the entire living biomass of forest and does not pose any major difficulties in terms of logistics during field measurements (Intergovernmental Panel on Climate Change (IPCC), 2007).

Despite the enormous usefulness of forest, it is being destroyed at a startling rate Tropical forest has furthermore been reported to contribute approximately 20% of CO_2 emissions caused by anthropogenic effect to the atmosphere via deforestation in the tropics (Houghton *et al.,* 2001). As at 2005, deforestation rate in Nigeria is highest globally (FAO, 2006). Fifty-five percent of its primary forests was lost between 2000 and 2005, and the rate of change in forests increased from 3.12% to 31.2% each year. The destruction of the forest is propelled by anthropogenic effects such as farming, increasing population, fuelwood gathering, logging, road building as well as hydropower development (Kaewkrom *et al.,* 2011). The tree biomass, understory flora, and soil organic matter in the forest constitute the key pool of carbon (Vashum and Jayakumar, 2012)

2.2 Deforestation and Degradation of forest

The anthropogenic factor is the principal cause of both deforestation and degradation that directly impact on forest cover subsequently culminating into the loss of stocks of carbon. Agriculture is projected to be the major driver of deforestation constituting about 80% globally. Mechanized agriculture is the principal deforestation driver in Latin America (constituting about 2/3 over-all deforested area). It amounts to one third of Africa and tropical Asia's deforestation and is of comparable significance to subsistence agriculture. Urbanization, Mining, infrastructural development are significant but not so prominent. Reports on global degradation patterns suggests timber extraction and selective exploitation of economic woody species make up over 70% of over-all Latin America and (sub) tropical Asia forest degradation. Fuelwood gathering, production of charcoal, and grazing in forests are the leading drivers of degradation in major parts of Africa (Kissinger *et al*., 2012). Secondary drivers are multifarious connections of social, economic, political, cultural and technological processes that affect the major drivers to cause deforestation or forest degradation (Geist and Lambin, 2002). They act at numerous scales from international; markets, commodity prices, to national; increase in population, local markets, state policies, governance and local conditions; sustenance, poverty. Furthermore, Kissinger *et al*. (2012) reported that growing economy based on the trade of primary commodities, such as timber and agricultural produces in a global economy is critical secondary driver.

More lately, it is evident that commercial actors play a pivotal role in agricultural expansion into forests and for numerous countries, mechanized agriculture is leading over small scall agriculture (Boucher *et al*., 2011) especially in the Amazon region and Southeast Asia. Here agroindustry, increasingly producing for international markets (cattle ranching, soybean farming, and oil palm plantations) were recognized as core drivers of post-1990 deforestation (Rudel *et al*., 2009; Boucher *et al*., 2011). Poor governance, corruption, Neglect to low ability of forestry agencies, uncertainties of land tenure systems, a nd inadequate or lack of natural resource planning and management can be critical und erlying influences of deforestation and degradation (Rademaekers *et al*., 2010).

The impact of Agriculture as an agent of deforestation and degradation is expansive. The FAO envisages a 70% rise in food demand 2050, with a resultant growth of 49% cereals produced and an 85% rise in meat production (FAO, 2009). Improving agricultural yields has been the major method for improved food production for several years, but intensification can also result more to deforestation in some situations (Rudel *et al*., 2009; Boucher *et al*., 2011). Foreign direct investment in land in the least developed countries in Africa and Southeast Asia due to global shortages of arable land is increasing and impacting on forests.

Furthermore, considering deforestation and degradation in relation to energy sources in developing countries, developing economies are exceeding developed economies in economic development and gross domestic product growth, which accounted for all the total rise in world's cr ude oil consumption in the last ten years (World Bank, 2012). This rise in consumptio n of oil is a signal to the increasing energy demand and mineral resource, nonetheless, the fragility of economy to collapse in oil prices may probably make alternative source of energy, for example biofuels and wood, more cheap attractive in the future thereby mounting pressure on forest as an energy source. Klenk *et al*. (2012) reported that signi ficant changes in manner of fuelwood use worldwide in the last decade. The report sug gests significant increase of wood for energy in Africa and Latin America, however, it has declined in Asia by approximately half, reflecting a pattern of increasing developme nt and avaliabilty of alternative fuel source to households in these countries. Hofstad *et al*. (2009) opined that use of wood for energy domestically might persist for the next two decades, also, the charcoal demand will probably surge as a result of anticipated urbanization rise. There are levels of uncertainties to the amount of emissions from greenhouse gases linked to deforestation and degraded forest globally. This is projected at between 10% to 40% of the 1.4 $PgCy^{-1}$ of the total carbon emitted from tropics (1990 to 2000) (Houghton *et al.,* 2012)

2.3 The concept of climate change

Generally climate is defined as the average condition of the atmosphere for a given time scale (hour, day, month, season, year, a decade and so forth) and usually for a definite geographical region (Houghton, 2002).

Global climate has not been stable in either historical or geologic time scales. The historical record illustrates abundant instances of change in climate. For instance, throughout the Roman Warm Period (250 BC–400 AD), the climate was favorable to agriculture in northwest Europe and the Mediterranean, with vineyards in what's now Britain and olive production region of Turkey, where winter is just too severe for those crops. (Ashby and Pachico, 2012).

There is strong indications that change in climate, in the shape of atmospheric warming due to the greenhouse effect, is going on today. Over the last century, increased temperature have been reported nearly everywhere; over land, on the ocean and within the ocean air. The trend has hasten subsequently in the 1970s. An increase of 0.74° C have been reported in the Mean global land temperatures over the past century. The world is near to being warmer than it's been for over 1,000 years and temperatures aren't far from the upper limit of the temperature range of the last 400,000 years. (Ashby and Pachico, 2012)

Behavioral chances in flora and faunas are in step with a warming climate. Consistent with Audubon Society, in excess of 60% of migrating species of bird in North America have increased their winter range towards the north by a mean of 35 miles within the four decades, showing in general, warmer environments. Season creep—earlier springs and later autumns—has also result to the sooner flowering of several wild flora species as springtime warming occurs earlier in high latitudes. As Oceans warms up, Coral reefs are dying off (Wilkinson, 2008).

Furthermore, pattern of rainfall in the past century paints a multifaceted picture. Gradual increase in precipitation have been observed in northern latitudes, meanwhile, a sliding trend in rainfall have been reported in south of Africa and regions of southern Asia since the 1970s. Reports have also indicated in the Sahel a major decrease in rainfall (region between the Sahara Desert, north and the southern region of Sudanian Savanna as of 1920). Furthermore, within the tropical and subtropical region, droughts became longer, more severe and affected longer range of area as a result of the aggregate consequences of reduced precipitation, and increased water requirements by crops due to higher temperatures (IPCC, 2007).

2.4 Causes of Climate change

Anthropogenic effects are the major source of global climate change. These disturbances are principally consequence from emissions related to use of energy, but locally and regionally, urban growth and changes in land use are also a critical factor (Karl and Trenberth, 2003). However, myriads of factor results in climate change and come about over varying time scales. For instance, eccentricities in the orbit of the earth round the sun and shifts in its tilt toward the sun affect the amount of heat it receives. Referred to as Milankovitch Cycles, and supported by reports from ice cores and sediments studies, it has been observed that this changes had implications on change in climate for thousands of years. In the 1970s, forecasts based on these cycles predicted that the Earth was on the verge of entering a cooling period, so these cycles are not responsible for ongoing global warming (Herring, 2007).

Furthermore, change in climate is also affected by the quantity of heat the sun emits, there are steady cycles in amount of warmth radiated by the sun that reaches Earth. Differences in this cycles have been noted to have corresponded with variations observed in worldwide temperature and have been sustained in about a decade's up-and-down series whereas there has been a steady rise in the globe's warmth rather than a trend of the sunspot cycles. Although there is dearth of understanding about variations in emission pattern of the sun, the recent convention shows that a rise warmth radiated by the sun is of less significant influence to global heating compared to variations in the earth's atmosphere (IPCC, 2007). According to Ashby and Pachico (2012), the content of the atmosphere is strongly associated with variation in the global climate. For about, 400,000 years, the quantity of CO_2 the earth's atmosphere and global temperature are closely linked. During this era, four climax temperature data have corresponded with four climax concentrations of CO_2 within the atmosphere. In the same way, when there's reduced amount of CO_2 concentrations in the atmosphere, temperatures becomes cooler. Consequently, CO_2 is said to possess a greenhouse influence on the globe's warming. Majority of climate experts accept as true that current swift variations within the atmosphere are liable for recently perceived warming climate.

2.5 Greenhouse gases

The primary cause of recent warming climate is understood be as a result of the increase in concentration of CO_2 and other greenhouse gases including water vapour (~60%), others include trace gases such as methane and nitrous oxide within the atmosphere. These gases trap and clench solar heat, in turn warming up the air. Increase in the concentration of greenhouse gases within the atmosphere, leads to a surge in heat clenched and consequently results in greater global warming.

Carbon dioxide has triggered majority of the global warming, and its sway is predicted to continue. For instance, concentration in the last decade in the atmosphere was 389 ppm, on top of any shown in ice cores which holds illustrations of the globe's atmosphere for the past 650,000 years. Throughout that age, CO_2 concentration differed between a low 180 ppm to high 270 ppm. Throughout the past 20,000 millennia, CO_2 levels have never passed 300 ppm however, concentrations are now soaring fast. A figure of 313 ppm was reported in 1960, 389 ppm in 2010, current figures stands at 417 ppm. (IPCC 2007; Scripps institute of Oceanography, 2020). While volcanic activity existed as the first source of high levels of the CO_2 within the atmosphere, currently the main explanation for the rise in CO_2 emissions is anthropogenic. Presently, volcanoes add less than 1% of CO_2 emissions going into the atmosphere.

Carbon dioxide worldwide emission has reached 34 billion tons as at 2011, the figure that continues to rise. Ever since, a sum total of 420 billion tonnes of CO_2 has been cumulatively emitted as a result of anthropogenic factors. Report suggests that reducing the mean worldwide temperature increase to 2 percent above pre-industrial levels based on the goal globally adopted in United Nation climate dialogues is feasible. This can be achieved provided aggregate emissions in the 2000–2050 period remain below 1000 to 1500 billion tonnes of CO_2. However, if the status quo continues, overall emissions will exceed 1500 billion tonnes inside the next 20 years. (Jos *et al*., 2012).

2.6 Roles of forest in climate change

Measures set in motion to reduce or prevent drivers of change in climate primarily through the reduction of the concetration of greenhouse gases with the atmosphere constitute what climate change mitigation is all about (Ashby and Pachico 2012).

Forest ecosystem plays a pivotal role in mitigating change in climate when it is sustainably managed. Forest have the potential to sink approximately a tenth of world-wide carbon emissions being anticipated in the first half of the current century into their biomass, soil, and products and retain them in principle in perpetuity. (FAO, 2016). Forests absorb carbon at a rate determined by several factors, this include but not limited to forest types, location and age of forest. Forests houses huge quantities of carbon in trees (above and belowground), understory vegetation, and soil. Worldwide, they store carbon up 1.2 trillion tonnes, just over 50% of the total in terrestrial vegetation and soil (FAO, 2013).

Broadly speaking, young, developing and well-managed forests are decent carbon sinks. Tropical forest species sink carbon at a greater proportion than most forests types, not all forests types are good carbon sinks. The unabated loss of forest biodiversity, though, wanes the capacity of forest ecosystems to respond to drastic changes occurring. Furthermore, dearth of knowledge on the conservation and maintainable and sustainable use of forests in the context of change in climate is a hindrance to recognising concerns, necessities, and primacies for action.

2.7 The cycling of carbon in the forest

Knowledge about carbon cycle globally including its interferences through anthropogenic factors is vital for creating feasible strategies for mitigating change in climate. (Lal, 2008). Carbon is vital nutrient requirement for structure of entire organic compounds, this is fixed through photosynthesis. (Rose, 2009). As this process happens, more concentrations of CO_2 is sunk as biomass from the atmosphere where it occurs as gas, thus dipping carbon within the atmosphere and storing it in plant tissues both above and below ground (Rose, 2009).

However, enormous amount of sequestered carbon in forest ecosystems from several decades can be released to the atmosphere within a short period (Schulze *et al.,* 2000; Page *et al.*, 2002; Korner, 2003). Furthermore, plants release CO_2 as waste from the breakdown of organic molecules as their cells derive energy from oxidization of molecules holding fixed carbon back into the atmosphere thus carbon cycle is a continuum. Moreover, surface layer of soil in forests are rich in organic matter made chiefly of plant litter at varying stages of decay. These standing litter layer including the soil are thought to be extremely active in carbon cycling in forest, practically in response to disturbance (Yanai *et al.*, 2003). Pregitzer and Euskirchen (2004) in their research on storage of carbon and nutrient cycling, they opined that at the biome level, the forest mean carbon sink remain moderately the same or rise with age, and average carbon in forest floor reached a peak in all three biomes studied after approximately 70 years of stand development.

2.8 Carbon Pools and Sequestration

Carbon reservoirs where carbon is stored for a long term. Plant act as sink when the plant takes CO_2 from the atmosphere for building up of their biomass through the process of photosynthesis. Five carbon reservoirs (pools) have been identified globally, they include the Ocean reservoir (pool); this is estimated to be up 38000 Pg, projected to be increasing at the rate of 2.3 Pg C yr^{-1}. The second, is the geologic carbon reservoir, consisting of fossil fuel, this pool is estimated to hold 4,130 Pg, from this 85% is coal, oil is 5.5%, and 3.3% is gas. Verified stashes of fossil fuel comprise about 678 Pg of coal (3.2 Pg yr^{-1} production), oil is around 146 Pg (3.6 Pg yr^{-1} of production), and natural gas makes 98 Pg of the staches (1.5 Pg yr^{-1} of production) (Schrag 2007). The Third is Pedologic reservoir. Batjes (1996) estimated it at 2,500 Pg up to 1 m depth. It comprises of two separate components, first of it is soil organic carbon (SOC) reservoir estimated at 1,550 Pg and second of it is soil inorganic carbon (SIC) reservoir estimated at 950 Pg. The SOC reservoir comprises extremely lively humus and somewhat inert charcoal carbon. It includes a mix of (a.) flora and fauna residues at various phases of decay; (b) materials produced microbiologically and/or chemically from the break down products; and (c) the remains of dead microorganisms and small animals and their decaying products (Schnitzer, 1991). Atmospheric reservoir is the fourth, with 760 Pg of carbon dioxide carbon and growing at 3.5 Pg C yr^{-1} or 0.46% yr^{-1}. The biotic pool is the fifth reservoir, it is estimated at 560 Pg. Both the pedologic and biotic carbon reservoir is together referred to as the terrestrial carbon reservoir (pool) estimated at roughly 2,860 Pg. The core carbon reservoir located in the tropical forest ecosystems are the living tree biomass (Above and below ground) of trees, understorey vegetation, dead mass of standing litter, woody remains and soil organic matter (Krisnawati and Imanuddin, 2011)

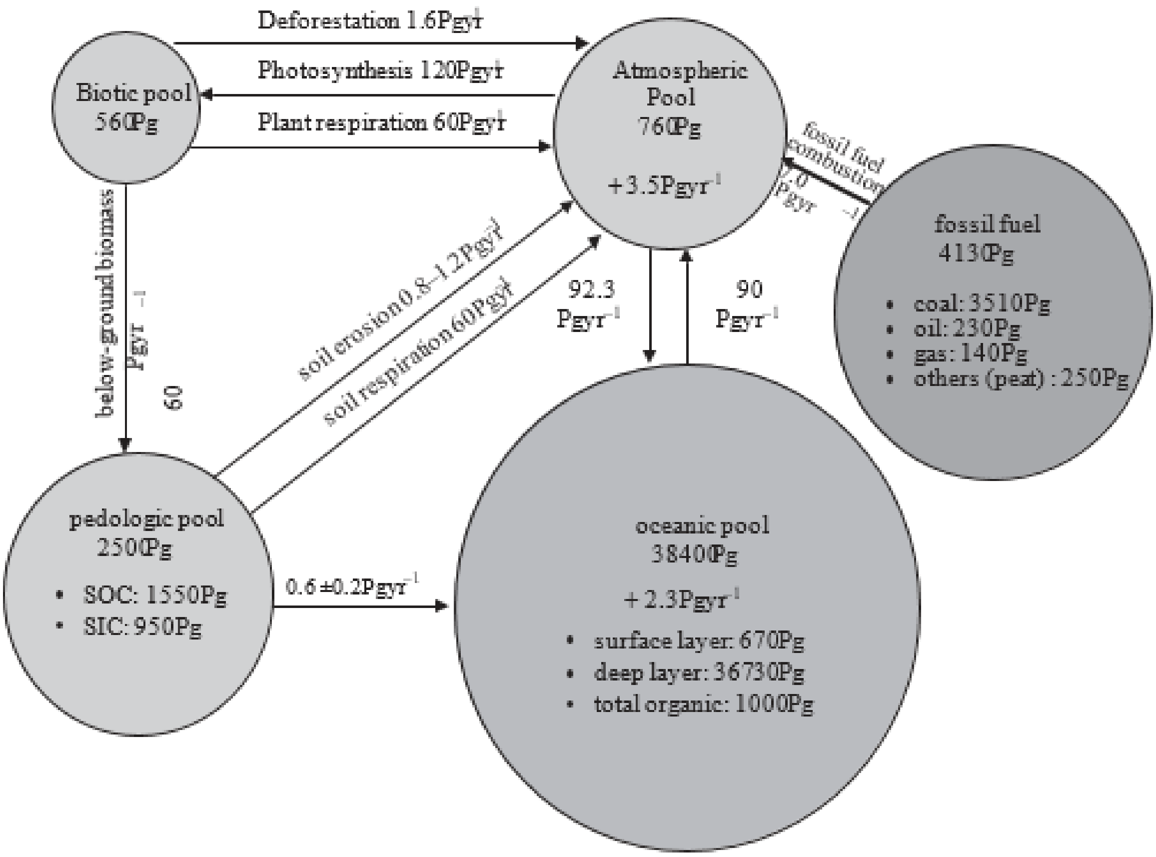

Figure 2.1: Global carbon pools

2.9 Biomass Estimation

The most accurate procedure to measure the carbon storage in aboveground living biomass is to reap completely trees in identified sites. The reaped species are dried, biomass are in turn weighed. Carbon reserves in each species are assessed from the biomass dried by taking 50 percent of the biomass weight (carbon content is approximately 50% of biomass (Westlake, 1966). Moreover, this method is precise for a specific site, it is excessively inefficient, strenuous, costly, destructive and impracticable for country level analyses (Gibbs *et al.*, 2007). However, non-destructive estimation of forest biomass by the use of allometric equations is the most generally adopted method. Equations are established and used for forest to evaluate the living tree biomass and carbon storage of different forest (Vashum and Jayakumar, 2012)

There are generalized aboveground forest tree biomass estimation cum predictor for several forest types and tree species (Brown*, et al.*, 1989; Nelson *et al.*, 2000; Chung-Wang and Ceuleman, 2004; Navar, 2009). These are established through relationships of various parameters of trees such as diameter of trees at breast height, height, diameter of crown to mention a few. Worldwide comparison can be made based on various calculations and equations developed for specific species and for a combination of different species. (Vashum and Jayakumar, 2012).

CHAPTER THREE

MATERIALS AND METHOD

3.1 Study Area

3.1.1 Location, Topography, Drainage, and Soil of the study area

The study was conducted in Ibodi Monkey Forest (IMF), of Osun State Nigeria, 442 m above sea level (Fig. 1). IMF is located on the latitudinal and longitudinal 7°35 N, 4°40'E and 07° 35.161'N, 004°40.548'E respectively. The area covers about about 0.5 km^2. It consists of clusters of contiguous forested areas with bounderies such as river, manmade features like roads that delineated it. The soils are fine textured and well-drained, with uniform brownish to red or dark brown colour to depth which is resultant from amphibolite and other associated basic rocks. Ibodi Monkey forest has been preserved traditionally by local priests through a strict law prohibiting logging. The forest in time past has different names before the intervention of the government ten years ago (Komolafe, 2015). It has been formerly called by several names such as IGBO AIWO (a bush no one must enter), IGBO OLUWA (God's forest) (Komolafe, 2015).

3.1.2 Climate and Vegetation of the study area

Ibodi experiences a tropical climate with prominent wet and dry seasons. Average annual rainfall and temperature are 1157 mm and of 26.1°C respectively. The rainy season generally lasts for about eight months (March – October) while the dry season occurs between November and February. The vegetation is archetypal tropical rain forest, though slightly modified as a result of human activities; yet the three layers of the forest can still be recognised. The lower part form the undergrowth where the vegetation is most dense. Species include herbs, shrubs, and grasses. The middle layer consists of heavily branched tall trees ranging between 15 to 30 meters in height. They are with well-developed and dark green foliage to form an extensive canopy of evergreen foliage. The top layers (the most prominent) are made up of tall trees between 35-60 meters in height. The leaves are usually in few branches at the top of the trees.

Due to the agricultural activities at the fringes of the forests the study site include both cash crops and fruit crops, and forest species. In the category of the tree or cash crops are orange (*Citrus spp*), cocoa (*Theobroma cacao*), kola nut (*Cola spp*) and palm oil (*Elaeis guineensis*). Among the food crops at site as at the time of the reconnaissance survey, are cassava (*Manihot esculenta*), cocoa yam (*Xanthosoma esculentum*), and banana (*Musa spp*). Forest species found during the survey includes *Albizia zygia*, *Baphia nitida*, *Ficus exasperata*, *Funtumia elastica* etc.

3.2 Selection of plots

There are three major physiognomies in Ibodi Monkey Forest (IMF) identified during the reconnaissance survey in 2013 these are; Regrowth forest (RF), Tree Fallow (TF); (an area of farmlands left to fallow over a period of 20 years) and Cocoa Plantation (CP). Twelve 25 m x 25 m plots were randomly located, four plots in each of the three physiognomies. A complete enumeration of these plots were done to determine the temporal changes in each physiognomy by comparing with the baseline studies. A measuring tape was used to lay out the plots, the boundaries were demarcated with pegs. The coordinates of each plots were determined with a global positioning system (GPS) with model GARMIN (GPS MAP 78).

Table 3.1: Geographical location of each plot at Ibodi Monkey Forest

PHYSIOGNOMY and PLOTS		PLOT LOCATIONS
RF	**A_1**	07^0 35.471' N, 004^0 40.591' E
	A_2	07^0 35·449' N, 004^0 40.618' E
	A_3	07^0 35.391' N, 004^0 40.606' E
	A_4	07˚35.414'N, 004˚40.622'E
CP	**B_1**	07˚3.35.369'N, 004˚40.605'E
	B_2	07˚35.367'N, 004˚40.625'E
	B_3	07˚35.191'N, 004˚40.37'E
	B_4	07˚35.352'N, 004˚40.404'E
TF	**C_1**	07˚3.35.291'N, 004˚40.564'E
	C_2	07˚35.288'N, 004˚40.573'E
	C_3	07˚35.171'N, 004˚40.541'E
	C_4	07˚35.161'N, 004˚40.548'E

Where A_{1-4}, B_{1-4}, and C_{1-4} represent the plots randomly chosen in each of the physiognomies.

RF – Regrowth forest

CP – Cocoa plantation

TF – Tree fallow

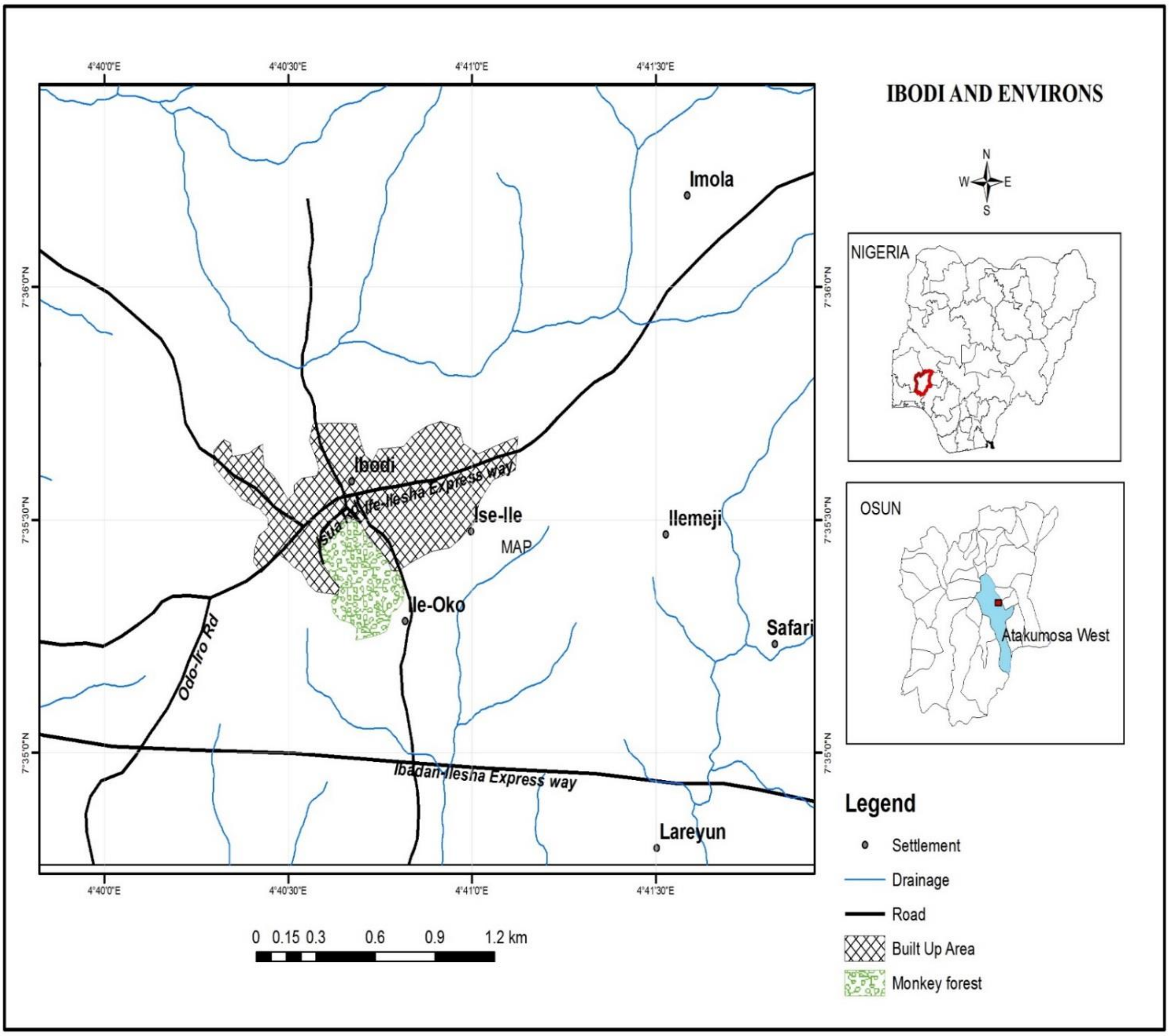

Figure 3.1: Map of Ibodi Monkey Forest Ibodi, Atakumosa West Local Government Area of Osun State, Nigeria

3.3 Method of Data Collection

At every plot, all standing trees, DBH $\geq$10 cm were identified, measured and recorded. A diagonal transect was laid within the sample plot for soil sample collection. Soil sa mples were taken from four soil depths of 0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm at three points (i.e. at the two edges and middle of the transect line). Soil sample s from the same depths and from the same plot were pooled and thoroughly mixed to fo rm a composite soil sample, from which subsamples were collected for laboratory anal ysis.

3.3.1 *Tree Species Identification*

The botanical name of every standing tree enumerated in each sample plot were recorded in each of the study sites. When a tree's botanical name was not known immediately, it was identified by its commercial or local name. Such commercial or local name was translated to correct botanical names using Keay (1989) and taken to University of Ibadan Herbarium for authentication. Each tree was recorded individually in the field and possible effort was made not to omit any eligible stem in a sample plot. This was because any species omitted will indicate the absence of such species in the ecosystem.

3.3.2 Basal Area Estimation

Tree basal area in all selected plots in the selected study area were calculated using the formula:

$$BA = \frac{\pi D^2}{4} \quad \text{...(1)}$$

Where BA = Basal area (m^2), D = Diameter at breast height (cm) and π = Pie (3.142).

The total basal area for each of the sample plots was obtained by the sum of the BA of all trees in the plot.

The Basal area per obtained per plot was converted to BA per hectare by multiplying mean basal area per plot with the number of 25×25 m plots in a hectare (16).

$$BA_{ha} = \overline{BA_P} \times 16 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where BA_{ha} = basal area per hectare.

$\overline{BA_P}$ = Mean basal area per plot

3.3.3 Tree Species Classification and Biodiversity Indices

(i) The relative density of the species was computed as:

$$RD = \frac{n_i}{N} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

RD = species relative density

n_i = number of individual of species i

N = total number of all tree species in the entire community.

(ii) Species relative dominance (RD_O (%)) was computed using the equation:

$$RD_O = \frac{\sum Ba_i \times 100}{\sum Ba_n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where: Ba_i = basal area of individual tree belonging to species i

Ba_n = Individual stand basal area

(iii) Species diversity index was calculated using the Shannon-Wiener diversity index (Kent and Coker, 1992):

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i) \quad (5)$$

Where:

H' = Shannon-Wiener diversity index

S = Total number of species in the community

P_i = Proportion of S made up of the i^{th} species

ln = natural logarithm

(iv) Shannon's maximum diversity index was calculated using the relationship between total number of species and Shannon-Wiener diversity index:

$$H_{max} = \ln(S) \quad (6)$$

Where

H_{max} = Shannon's maximum diversity

S = Total number of species in the community

(v) Species evenness in each community was determined using Shannon's equitability (E_H):

$$E_H = \frac{H'}{H_{Max}} = \frac{\sum_{i=1}^{S} P_i \ln(P_i)}{\ln(S)} \quad (7)$$

(vi) Mangalef's index was calculated using the equation below:

$$D = \frac{G-1}{\ln k} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where

D = Mangalef's index

G = Species number

K = Number of individuals

(vii) **Sorenson's similarity Index (SI)**

$$S.I = \frac{2G}{A+B} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where G = species common to both communities

A = count of species present in community X

B = count of species present in community Y

While X and Y are two different communities being studied.

(viii) Family Importance Value (FIV)

The Family Importance Value (FIV) was used to understand a family's share in the tre e community. FIV is defined as the sum of its relative dominance (RDm), its relative d ensity (RD) and its relative frequency (RF), which is

Calculated as follows:

$$RD_m = \frac{\text{Total basal area for a family}}{\text{Total basal area for all families}} X.100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

$$RD = \frac{\text{Number of individual of a family}}{\text{total number of all individual}} X.100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

$$RF = \frac{\text{Frequency of a family}}{\text{sum frequencies of all families}} \text{X.100} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Thus, Family Importance Value = RDm + RD + RF ………………….. (13)

3.4 Biomass and Carbon Stock Estimation

3.4.1 Estimation of Aboveground biomass of Woody Species

The following parameters will be used to determine the aboveground biomass of woody species encountered within the sampling plots across the different study sites; (i) Heights (ii) Specific wood gravity (iii) Diameter at breast height (iv) Allometric equation.

3.4.2 Height Estimation

Erect span between the lowermost part and the highest standing part of all trees >3 m in height was measured. Haglof clinometer was used to determine the height of the woody species.

3.4.3 Determination of Specific wood gravity

Species specific gravity was determined from the tree core samples. Due to the fact that destructive sampling could not be carried out because of the status of the forest in the s tudy area we collected three wood cores at heights 1 m and 1.4 m above ground level f rom each species using an increment borer. Core volume was measured by water displ acement and anhydrous mass was obtained after drying to constant weight at 105 °C. Basic wood density was determined as the anhydrous mass of a wood sample per unit volume:

$$\rho = \frac{m}{v} \qquad \ldots\ldots\ldots\ldots\ldots\ldots.. (14)$$

where ρ = basic wood density ($g.cm^{-3}$); m and v, sample anhydrous mass (g) and volu me (cm^3) respectively. Density was averaged across all three cores per sample to deter mine specific wood density.

3.4.3 Selection of Allometric Equation

The choice of the allometric equation used in this study involved an assessment of five allometric equations that were developed for moist forests. Allometric equations without height were not considered because they can be influenced by environmental stress parameters which could introduce bias (Kenzo *et al.*, 2015). Allometric equations considered were those that quantitatively formalize proportionality relationship between woody species diameter at breast height, height and specific gravity.

Allometric equations assessed were:

1. $Biomass = 0.0509 \times (\rho) \times ((DBH)^2) \times H$

(Chave *et al.*, 2005) … **(15)**

2. $Biomass = 0.0347 \times (\rho)^2 \times (DBH)^2 \times H$

(Henry *et al*, 2010) … **(16)**

3. $Biomass = \exp(-2.436) + (0.1399 \times \ln (DBH)^2) + (0.7373 \times (\ln (DBH)^2) \text{ x } H) + (0.279 \times \ln (\rho)$

(Djomo *et al.*, 2010) … **(17)**

4. $Biomass = \exp(-2.9205) + (0.9894 \times \ln ((DBH^2)) \times \rho \times H)$

(Feldpausch *et al.*, 2012) … **(18)**

5. $Biomass = 0.0673 \times ((\rho \times (DBH)^2 \times H))^{0.976}$

(Chave *et al.*, 2014)… **(19)**

Where, ρ = Wood specific gravity;

DBH = woody species diameter at breast height;

H = woody species height

Assessment of the allometric equations was done using each of the equations to generate aboveground biomass estimates for woody species (with DBH $\geq$ 10 cm) within the sampling plots. The allometric equation that best accurately predicts the aboveground biomass with minimal error was obtained using multiple regression analysis and coefficient of variation was used to describe the inherent heterogeneity in aboveground biomass estimates (Dominguez-Calleros *et al*, 2016).

3.4.4 **Carbon stock estimation in aboveground pool**

The amount of carbon in each woody species is approximately 50% from the total aboveground biomass (Hirata *et al.,* 2012). In lieu of this, the conversion of biomass to carbon stock was done by applying the conversion factor of 0.5 based on the equation below:

$C\,(ton) = AGB \times CF$ ………………. **(20)**

Where:

C = carbon stock ($tCha^{-1}$)

AGB = above ground biomass (t)

CF = carbon fraction (0.5)

3.4.5 Evaluation of Belowground Biomass

Belowground biomass was estimated at 15% of the aboveground biomass (MacDicken, 1997; Mokany *et al.*, 2006).

The total biomass of each site were estimated by summing up the amount of biomass of each species in the area (ha) in the study sites and multiplied with the total size of the forest.

Biomass values were converted to carbon stocks using 0.5 carbon fractions as default values (MacDicken, 1997; Penman, 2003; IPCC, 2006) and expressed in t/ha.

3.5 Assessment of Biomass in the aboveground and carbon storage in the understory in all the three physiognomies

Estimation of the carbon stock in the growth forms of the understory, such as herbs and shr ubs was done by laying five transects systematically in each physiognomy and a quadrat o f 1 m × 1 m was established at every 2 m point to identify the understory plant species present in each plot. Aboveground biomass was collected by clipping at 2 cm above the ground. The collected shrubs and herbaceous plants were transported to the laboratory, oven dried to a constant weight at 70 °C and weighed .The loss on ignition (LOI) was used for estimating the organic carbon content (Dean, 1974). Biomass of other growth forms were calculated in all the sites by multiplying the concentrations of total C with the corresponding dry weights and converted to $t \cdot ha^{-1}$.

Carbon stock in the understory was calculated by multiplying organic carbon estimates by a Carbon Fraction default value of $0.47\ t \cdot C \cdot t^{-1}$ (IPCC, 2006)

3.6 Standing forest floor litter collection

In order to quantify carbon stock in Litter, standing floor litter was randomly collected at five points using a 50 cm x 50 cm quadrat size. The litter collected inside the quadrat was separated into leaves, wood, reproductive organs (flowers and fruits) and thrash (those that could not be easily classified into any of the above components), oven dried at 60 °C until constant weight was achieved and milled for analysis. The ground leaf and wood standing floor litter components were analyzed to determine organic carbon. The loss on ignition (LOI) was used for estimating the organic carbon content (Dean, 1974).The reproductive and trash components were discarded. Biomass of standing floor litter was calculated in all the sites by multiplying the concentrations of total C with the corresponding dry weights and converted to $t \cdot ha^{-1}$.

Carbon stock in the standing Litter was calculated by multiplying organic carbon estimates by a Carbon Fraction default value of $0.47\ t \cdot C \cdot t^{-1}$ (IPCC, 2006)

3.7 Soil carbon stock estimation

Each samples were collected at different depths up to 60 cm. Organic carbon was determ ined using the Walkley−Black method. Samples collected for bulk density were ov en−dried for 24 h at 105 °C and their bulk density determined as the ratio of the o ven dried mass of the sample to its volume. Soil carbon stock (SCS) was calculated der ived using the equation proposed by Broos and Baldock (2008)

$$SOC = OC \times \rho \times d \qquad \text{.....................(21)}$$

SOC = Soil organic carbon ($t \cdot ha^{-1}$)

OC = Organic C content (%)

ρ = soil bulk density ($g \cdot cm^{-3}$)

d = depth (m)

3.8 Estimation of carbon sink (sequestration) potential of Ibodi monkey forest

The carbon stock in all the carbon pools was converted to tons of CO_2 equivalent by m ultiplying it by 44/12 or 3.667 (atomic weight difference between C and CO_2) so as to understand the climate change mitigation ability of the study site.

$\mathbf{CO_{2etotal}} = C_{total} \times 3.667$ .... **(22)**

Where:

$\mathbf{CO_{2etotal}}$ = Carbon dioxide equivalent within all measured pools ($t.CO_{2e}.ha^{-1}$)

$\mathbf{C_{total}}$ = Carbon stocks in all measured pools ($t\ C\ ha^{-1}$)

3.667 = Conversion factor to convert Carbon into Carbon Dioxide

3.9 Statistical Analysis

Results obtained was subjected to appropriate descriptive and inferential statistics. One way analysis of variance was employed to test for significant difference between carbon stock in aboveground biomass, soil and in the standing floor litter across the different vegetation. Means of the main effects were compared using Least Significant Difference (LSD), using SPSS 17.0 software package.

CHAPTER FOUR

RESULTS

4.1- Floristic Pattern and composition of the study area

4.1.1 Composition of Species encountered

The species composition of each of the twelve (12) study plots is presented in Tables 4.1 to 4.3. A total of One Hundred and ninety-one (191) individual species were recorded in all the three physiognomies out of which eighty-seven (87) species were encountered in the regrowth forest physiognomy (RF) (Table 4.1) eighty-six (86) species in the Cocoa plantation physiognomy (CP) (Table 4.2) and One hundred and six (106) species in the Tree fallow physiognomy (TF) (Table 4.3). Furthermore, Sixty-five (65) families were encountered in all the three physiognomies out of which Forty-three (43) families were represented in the RF, Thirty-nine (39) families in the CP and Forty-four (44) families in the TF. Dominant families in the study includes Euphorbiaceae (13 species), Moraceae (12 species), Apocynaceae (11 species), Papilionaceae (9 species), Asteraceae and Rubiaceae (8 species), Cucurbitaceae and Sterculiaceae (7 species), Acanthaceae, Malvaceae and Sapindaceae (6 species), Mimosaceae (5 species) and others (92 species) (Figure 4.1)

Table 4.1- Plant species encountered in the Regrowth forest physiognomy of Ibodi monkey forest, Ibodi, Osun State.

S/ N	NAME	FAMILY	HABIT	PLOTS A	B	C	D
1	*Acanthus montanus* (Nees) T. Anderson	Acanthaceae	H	-	-	-	+
2	*Adenia cissampeloides* (Planch. ex Hook.)	Passifloraceae	C	-	+	-	-
3	*Alafia barteri* Oliv.	Apocynaceae	C	+	+	-	+
4	*Albizia zygia* (DC.) J.F. Macbr.	Mimosaceae	T	-	-	+	-
5	*Alchornea cordifolia* (Schumach. et Thonn.) Mull. Arg.	Euphorbiaceae	S	-	+	-	-
6	*Alchornea laxiflora* (Benth.) Pax et K. Hoffm.	Euphorbiaceae	S	-	-	+	-
7	*Alstonia boonei* De Wild.	Apocynaceae	T	-	+	-	-
8	*Anchomanes difformis* (Blume) Engl.	Araceae	S	-	-	-	-
9	*Antiaris toxicaria* A. Chev.	Moraceae	T	-	+	+	-
10	*Baissea axillaris* (Benth.) Hua	Apocynaceae	C	+	+	-	-
11	*Baphia nitida* Lood.	Papilionaceae	T	-	+	+	+
12	*Canthium sp* L.	Rubiaceae	T	+	-	-	-
13	*Cardiospermum grandiflorum* Sw.	Sapindaceae	C	-	+	-	-
14	*Carpolobia lutea* G. Don.	Polygalaceae	S	+	-	+	+
15	*Ceiba pentandra* (L.) Gaertn.	Baombacaceae	T	-	-	+	-
16	*Celtis mildbraedii* Engl.	Ulmaceae	T	+	-	+	-
17	*Celtis sp* Engl.	Ulmaceae	T	+	-	-	+
18	*Chassalia kolly* (Schumach) Hepper	Rubiaceae	H	+	+	+	+
19	*Chromolaena odorata* (L.) R.M. King et H. Rob.	Asteraceae	H	-	+	+	-
20	*Chrysophyllum albidium* G. Don.	Sapotaceae	T	+	-	-	+
21	*Cissus arguta* Hook. F.	Vitaceae	C	-	+	-	-
22	*Cissus quadrangularis* L.	Vitaceae	C	-	-	+	+
23	*Cnestis ferruginea* Vahl ex Dc.	Connaraceae	S	-	+	-	-
24	*Cola millenii* K. Schum.	Sterculiaceae	T	+	+	+	-
25	*Combretum hispidum* M.A. Lawson	Combretaceae	C	+	+	+	-
26	*Combretum paniculatum* Vent.	Combretaceae	C	-	+	-	-

27	*Combretum sp* Vent.	Combretaceae	C	-	-	-	+
28	*Cordia sp* L.	Boraginaceae	S	-	-	-	+
29	*Cyathula prostata* (L.) Blume	Amaranthaceae	H	-	+	+	+
30	*Dalbergiella welwitschii* (Baker) Baker.f.	Papilionaceae	S	-	+	-	+
31	*Deinbollia pinnata* (Po r. et Thonn.) Schumach. et Thonn.	Sapindaceae	S	-	-	+	+
32	*Dioscorea bulbifera* L.	Dioscoreaceae	C	-	-	+	-
33	*Diospyros Spp* Hiern	Ebenaceae	T	-	-	+	-
34	*Diospyros barteri* Hiern	Ebenaceae	T	+	+	+	+
35	*Diospyros sp* Hiern	Ebenaceae	T	+	-	-	+
36	*Dracaenea manii* Baker	Dracaenaceae	T	+	+	-	+
37	*Elaeis guineensis* Jacq.	Arecaceae	T	+	+	-	+
38	*Enathia chlorantha* Oliv.	Annonaceae	T	-	+	-	-
39	*Ficus exasperata* Vahl	Moraceae	T	-	+	-	-
40	*Ficus sp* Vahl	Moraceae	T	-	-	-	+
41	*Funtumia elastica* (Preuss) Stapf	Apocynaceae	T	-	+	+	-
42	*Grewia mollis* Juss.	Tiliaceae	S	-	+	-	-
43	*Hippocratea pallens* Planch. ex Oliv.	Celastraceae	C	-	-	+	+
44	*Hura crepitans* L.	Euphorbiaceae	T	-	-	-	+
45	*Icacina trichanta* Oliv.	Icacinaceae	H	+	+	+	+
46	*Jateorhiza macrantha* (Hook. f. et Mendon a) Excell et Mendon a	Menispermaceae	C	-	+	-	-
47	*Khaya grandifoliola* C. DC.	Meliaceae	T	-	-	+	-
48	*Landolphia owarrensis* P. Beauv.	Apocynaceae	C	+	-	-	-
49	*Lecaniodiscus cupanioides* Planch. ex Benth.	Sapindaceae	T	+	+	+	+
50	*Macaranga barteri* Mull. Arg.	Euphorbiaceae	S	-	-	+	-
51	*Melenthera scandens* (Schumach. et Thonn.) Roberty	Asteraceae	H	-	+	-	-
52	*Mezoneuron bentamianum* Baill.	Caesalpiniaceae	C	+	+	+	+
53	*Microdesmis puberula* Hook f. ex Planch.	Pandaceae	H	-	+	+	+
54	*Monodora myristica* (Gaertn.) Dunal	Annonaceae	T	+	+	-	+
55	*Morinda lucida* Benth.	Rubiaceae	T	+	-	+	-
56	*Morus mesozygia* Stapf.	Moraceae	T	+	-	-	-
57	*Motandra guineensis* (Thonn.) A. DC.	Apocynaceae	C	-	-	-	-

58	*Mucuna pruriens* (L.) DC.	Papilionaceae	C	-	+	-	-
59	*Myrianthus arboreus* P. Beauv.	Moraceae	T	-	+	-	-
60	*Napoleonaea vogelii* Hook. et Planch.	Lecythidiaceae	T	+	-	+	-
61	*Newbouldia laevis* (P. Beauv.) Seem. ex Bureau.	Bignoniaceae	T	-	+	-	+
62	*Oxytenanthera abyssinica* (A. Rich.) Munro	Poaceae	S	-	+	-	+
63	*Parquetina nigrescens* (Afzel.) Bullock	Periplocaceae	C	-	+	-	-
64	*Pentaclethra macrophylla* Benth.	Mimosaceae	T	+	-	+	-
65	*Phaulopsis falcisepala* C.B. Clarke	Acanthaceae	H	-	-	+	-
66	*Phytolacca dodecandra* L'Her	Phytolacaceae	H	-	-	-	+
67	*Pouzolzia guineensis* Benth.	Urticaceae	H	-	-	+	-
68	*Psychotria sp* L.	Rubiaceae	T	+	-	-	-
69	*Pterygota macrocarpa* K. Schum.	Sterculiaceae	T	+	-	+	+
70	*Pterygota sp* Schott & Endl.	Sterculiaceae	T	+	-	-	-
71	*Ricinodendron heudelotii* (Baill.) Pierre	Euphorbiaceae	T	-	-	-	+
72	*Rothmania hispida* (K. Schum.) Fager.	Rubiaceae	S	-	-	-	+
73	*Smilax kraussiana* Meisn.	Smilacaceae	C	+	+	+	-
74	*Sphenocentrum jollyanum* Pierre	Menispermaceae	S	+	-	+	+
75	*Sterculia rhinopetala* K. Schum.	Sterculiaceae	T	+	+	+	+
76	*Sterculia tragacantha* Lindl.	Sterculiaceae	T	-	-	+	-
77	*Strombosia pustulata* Oliv.	Olacaceae	T	+	-	-	-
78	*Strophanthus sarmentosus* DC.	Apocynaceae	C	+	-	-	-
79	*Tabernaemontana pachysiphon* Stapf.	Apocynaceae	T	+	+	+	+
80	*Tacca leontopentaloides* (L.) Kuntze	Taccaceae	H	-	-	-	+
81	*Tetrapleura tetraptera* (Schum. et Thonn.)	Mimosaceae	T	-	-	-	+
82	*Trichilia monedelpha* (Thonn.) J.J. De Wilde	Meliaceae	T	+	-	-	-
83	*Trichilia prieuriana* A. Juss.	Meliaceae	T	+	+	+	+
84	*Trilepisium madagascariensis* DC.	Moraceae	T	-	+	+	+
85	*Triplochiton scleroxylon* K. Schum.	Sterculiaceae	T	+	-	-	-
86	*Voacanga africana* Stapf.	Apocynaceae	T	+	+	-	+
87	*Zanthoxylum sp* L.	Rutaceae	T	+	+	-	+

A, B, C and D represents the four plots randomly selected in the Regrowth forest physiognomy
C- Climbers, H- Herbs, S- Shrubs, T- Trees

Table 4.2- Plant species encountered in the Cocoa plantation physiognomy of Ibodi monkey forest, Ibodi, Osun State

S/N	NAME	FAMILY	HABIT	PLOTS			
				A	B	C	D
1	*Acanthus montanus* (Nees) T. Anderson	Acanthaceae	Herb	+	+	+	+
2	*Adenia lobata* (Jacq.) Engl.	Passifloraceae	Climber	+	+	+	+
3	*Aerangis biloba* (Lindl.) Schltr.	Orchidaceae	Epiphyte	-	+	-	-
4	*Agelaea obliqua* (P. Beauv.) Baill.	Connaraceae	Shrub	-	+	-	-
5	*Albizia ferruginea* (Guill. et Perr.) Benth	Mimosaceae	Tree	+	-	-	-
6	*Albizia zygia* (DC.) J.F. Macbr.	Mimosaceae	Tree	+	+	+	+
7	*Alchornea laxiflora* (Benth.) Pax et K. Hoffm.	Euphorbiaceae	Shrub	+	+	-	+
8	*Allophylus aficanus* P. Beauv.	Sapindaceae	Tree	-	-	-	+
9	*Anchomanes difformis* (Blume) Engl.	Araceae	Shrub	+	+	-	-
10	*Antiaris africana* Engl.	Moraceae	Tree	-	+	-	-
11	*Antiaris toxicaria* A. Chev.	Moraceae	Tree	+	-	-	-
12	*Aspilia africana* (Pers.) C.D. Adams	Asteraceae	Herb	-	+	-	+
13	*Asystasia vogeliana* Benth.	Acanthaceae	Herb	+	+	+	+
14	*Bidens pilosa* L.	Asteraceae	Herb	+	-	-	-
15	*Borreria ocymoides* (Burm. F.) DC.	Rubiaceae	Herb	+	-	-	-
16	*Cardiospermum grandiflorum* Sw.	Sapindaceae	Climber	+	-	-	-
17	*Carica papaya* L.	Caricaceae	Shrub	+	-	-	-
18	*Chassalia kolly* (Schumach) Hepper	Rubiaceae	Herb	-	-	-	+
19	*Chromolaena odorata* (L.) R.M. King et H. Rob.	Asteraceae	Herb	+	+	+	-
20	*Cissampelos owariensis* P. Beauv. ex DC.	Menispermaceae	Climber	+	+	-	+
21	*Cissus arguta* Hook. F.	Vitaceae	Climber	+	+	+	+
22	*Clerodendrom volubile* P.Beauv.	Verbenaceae	Climber	-	+	+	-
23	*Cnestis ferruginea* Vahl ex Dc.	Connaraceae	Shrub	-	+	-	+
24	*Cola millenii* K. Schum.	Sterculiaceae	Tree	-	-	+	+
25	*Combretum hispidum* M.A. Lawson	Combretaceae	Climber	+	+	+	+
26	*Commelina benghalensis* L.	Commelinaceae	Herb	+	+	-	-
27	*Commelina diffusa* Burm. F.	Commelinaceae	Herb	-	-	-	+

28	*Costus afer* Ker-Gawl.	Costaceae	Shrub	+	+	-	+
29	*Cyathula prostata* (L.) Blume	Amaranthaceae	Herb	-	-	+	-
30	*Desmodium scorpiurius* (Sw.) Desv	Papilionaceae	Creeper	+	+	+	+
31	*Dioscorea bulbifera* L.	Dioscoreaceae	Climber	-	-	+	-
32	*Elaeis guineensis* Jacq.	Arecaceae	Tree	-	+	-	+
33	*Elytraria marginata* Vahl	Acanthaceae	Herb	-	-	+	-
34	*Ficus asperifolia* Miq.	Moraceae	Climber	-	+	-	-
35	*Ficus exasperata* Vahl	Moraceae	Tree	+	+	-	+
36	*Ficus lutea* Vahl	Moraceae	Tree (Epiphytic)	-	-	-	+
37	*Ficus mucuso* Welw.	Moraceae	Tree	-	+	-	-
38	*Ficus sur* Forssk.	Moraceae	Tree	-	-	+	-
39	*Gloriosa superba* L.	Colchicaceae	Climber	-	+	-	+
40	*Glyphaea brevis* (Spreng.) Monach.	Tiliaceae	Shrub	-	-	+	-
41	*Holarrhena floribunda* (G. Don et Schinz) T. Durand et Schinz	Apocynaceae	Tree	-	-	+	-
42	*Hoslundia opposita* Vahl.	Lamiaceae	Shrub	+	-	-	-
43	*Hypoestes* sp. L.	Acanthaceae	Herb	+	-	-	-
44	*Icacina trichanta* Oliv.	Icacinaceae	Herb	+	-	+	+
45	*Jateorhiza macrantha* (Hook. f. et Mendon a) Excell et Mendon a	Menispermaceae	Climber	+	-	-	-
46	*Laportea aestuans* (L.) Chew	Urticaceae	Herb	+	+	+	-
47	*Lecaniodiscus cupanioides* Planch. ex Benth.	Sapindaceae	Tree	-	-	+	-
48	*Leucaena leucocephala* (Lam.) de Wit	Mimosaceae	Tree	+	-	-	-
49	*Luffa acutangula* (L.) Roxb.	Cucurbitaceae	Climber	+	-	-	-
50	*Mallotus oppositifolius* (Geiseler) Mill. Arg.	Euphorbiaceae	Shrub	-	-	-	+
51	*Melenthera scandens* (Schumach. et Thonn.) Roberty	Asteraceae	Herb	+	+	-	-
52	*Mezoneuron benthanianum* Baill.	Caesalpiniaceae	Climber	+	-	-	+
53	*Milicia excelsa* (Welw.) C.C. Berg	Moraceae	Tree	-	+	+	-
54	*Momordica charantia* L.	Cucurbitaceae	Climber	+	+	+	+
55	*Momordica cissoides* Planch. ex Benth.	Cucurbitaceae	Climber	+	-	-	-
56	*Momordica foetida* Schum.	Cucurbitaceae	Climber	-	-	-	+
57	*Morinda lucida* Benth.	Rubiaceae	Tree	-	-	-	+

58	*Morus mesozygia* Stapf	Moraceae	Tree	-	+	-	-
59	*Mucuna pruriens* (L.) DC.	Papilionaceae	Climber	-	-	-	+
60	*Mucuna sloanei* Fawc. & Rendle	Fabaceae	Climber	-	+	-	-
61	*Nephrolepis spp*	Nephrolepidaceae	Fern	-	+	-	+
62	*Newbouldia laevis* (P.Beauv.) Seems. ex Bureu.	Bignoniaceae	Tree	-	-	+	+
63	*Oxytenanthera abyssinica* (A. Rich.) Munro	Poaceae	Shrub	-	+	-	-
64	*Panicum maximum* Jacq.	Poaceae	Grass	+	-	-	+
65	*Paullinia pinnata* L.	Sapindaceae	Climber	+	+	-	+
66	*Phaulopsis falcisepala* C.B. Clarke	Acanthaceae	Herb	-	+	+	+
67	*Phycanthus niruri* L.	Euphorbiaceae	Herb	+	-	-	+
68	*Piper guineense* Schumach et. Thonn.	Piperaceae	Climber	-	-	-	+
69	*Pouzolzia guineensis* Benth.	Urticaceae	Herb	+	+	+	-
70	*Psychotria spp*	Rubiaceae	Tree	-	-	+	-
71	*Rauvolfia vomitoria* Afzel.	Apocynaceae	Tree	+	+	+	+
72	*Senna hirsuta* L.	Caesalpiniaceae	Shrub	-	+	-	-
73	*Spathodea campanulata* P. Beauv.	Bignoniaceae	Tree	-	+	-	-
74	*Spondias mombin* L.	Anacardiaceae	Tree	-	+	-	+
75	*Sterculia tragacantha* Lindl.	Sterculiaceae	Tree	-	-	-	+
76	*Struchium spaganophorum* (L.) Kuntze	Asteraceae	Herb	+	-	-	-
77	*Syndrella nodiflora* (L.) Gaertn.	Asteraceae	Herb	+	+	-	-
78	*Tacca leontopetaloides* (L.) Kuntze	Taccaceae	Herb	-	-	-	+
79	*Theobroma cacao* L.	Sterculiaceae	Tree	+	+	+	-
80	*Tragia benthami* Baker	Euphorbiaceae	Climber	-	-	-	+
81	*Trema orientalis* (L.) Blume	Ulmaceae	Tree	+	-	-	-
82	*Trilepisium madagascariensis* DC.	Moraceae	Tree	-	-	-	+
83	*Vitex doniana* Sweet	Verbenaceae	Tree	-	+	-	+
84	*Vitex rivularis* Gurke	Verbenaceae	Tree	-	+	-	-
85	*Voacanga africana* Stapf.	Apocynaceae	Tree	+	+	-	+
86	*Xanthosoma esculenta* Schott	Araceae	Herb	+	+	+	+

A, B, C and D represents the four plots randomly selected in the Cocoa Plantation physiognomy

Table 4.3 - Plant species encountered in the **Tree fallow physiognomy** of Ibodi monkey forest, Ibodi, Osun State**.**

S/N	NAME	FAMILY	HABIT	PLOTS A	B	C	D
1	*Abelmoschus esulentus* (L.) Moench	Malvaceae	Herb	-	-	-	+
2	*Ageratum conyzoides* L.	Asteraceae	Herb	+	-	+	-
3	*Albizia zygia* (DC.) J.F. Macbr.	Mimosaceae	Tree	+	+	+	-
4	*Alchornea cordifolia* (Schumach. et Thonn.) Mull. Arg.	Euphorbiaceae	Shrub	+	+	-	-
5	*Alchornea laxiflora* (Benth.) Pax et K. Hoffm.	Euphorbiaceae	Shrub	+	+	-	+
6	*Anacardium occidentale* L.	Anacardiaceae	Tree	-	-	+	-
7	*Ananas comosus* (L.) Merrill	Bromeliaceae	Herb	-	-	+	-
8	*Anchomanes difformis* (Blume) Engl.	Araceae	Shrub	+	-	-	-
9	*Antiaris africana* Engl.	Moraceae	Tree	-	-	+	-
10	*Antiaris toxicaria* A. Chev.	Moraceae	Tree	+	+	-	-
11	*Aristolochia ringens* Vahl	Aristolochiaceae	Climber	+	+	-	-
12	*Aspilia africana* (Pers.) C.D.Adams	Asteraceae	Herb	-	-	+	+
13	*Asystasia gangetica* (L.) T. Anderson	Acanthaceae	Herb	+	+	+	+
14	*Asystasia vogeliana* Benth.	Acanthaceae	Herb	+	-	-	-
15	*Axonopus compressus* (Sw.) P. Beauv.	Poaceae	Herb/Grass	-	-	+	+
16	*Baphia nitida* Lodd.	Papilionaceae	Tree	+	-	-	+
17	*Blighia sapida* K.D. Koenig	Sapindaceae	Tree	+	-	+	+
18	*Bridelia ferruginea* Benth.	Euphorbiaceae	Tree	+	+	-	-
19	*Byrsocarpus coccineus* Schum. & Thonn.	Connaraceae	Climber	-	-	-	+
20	*Caladium bicolor Vent.*	Araceae	Herb	-	-	-	+
21	*Calopogonium mucunoides* Desv.	Papilionaceae	Tree	+	-	+	-
22	*Capsicum annuum* L.	Solanaceae	Herb	-	-	-	+
23	*Cardiospermum grandiflorum* Sw.	Sapindaceae	Climber	+	-	-	-
24	*Centosema pubescens* Benth.	Papilionaceae	Climber	-	+	-	-

25	*Chassalia Kolly* (Schumach.) Hepper	Rubiaceae	Shrub	+	+	-	-
26	*Chromolaena odorata* (L.) R.M. King et H. Rob.	Asteraceae	Herb	+	+	+	+
27	*Cissus arguta* Hook. F.	Vitaceae	Climber	+	-	-	-
28	*Citrus sinensis* (L) Osbeck	Rutaceae	Tree	-	-	+	-
29	*Clitoria ternatea* L.	Fabaceae	Herb	-	-	-	+
30	*Cnestis ferruginea* Vahl ex DC.	Connaraceae	Shrub	+	-	-	+
31	*Combretum hispidum* M.A. Lawson	Combretaceae	Climber	-	+	+	-
32	*Combretum paniculatum* Vent.	Combretaceae	Climber	-	+	-	-
33	*Combretum sp* Vent.	Combretaceae	Climber	+	-	-	-
34	*Crochorus olitorius* L.	Tiliaceae	Herb	-	-	+	-
35	*Cucurbita moschata* (Lam.) Poir.	Cucurbitaceae	Herb	-	-	-	+
36	*Cyathula prostrata* (L.) Blume	Amaranthaceae	Herb	-	-	+	-
37	*Dalbergiella welwitschii* (Baker) Baker.f.	Papilionaceae	Shrub	+	+	-	-
38	*Dioscorea bulbifera* L.	Dioscoreaceae	Climber	+	-	-	-
39	*Dioscorea dumetorum* (Kunth) Pax	Dioscoreaceae	Climber	-	-	-	+
40	*Dissotis erecta* (Guill. & Perr) Dandy.	Melastomataceae	Herb	-	-	-	+
41	*Eclipta prostata* L.	Asteraceae	Herb	-	-	-	+
42	*Elaeis guineensis* Jacq.	Arecaceae	Tree	+	-	-	-
43	*Ficus asperifolia* Miq.	Moraceae	Tree	+	+	-	-
44	*Ficus exasperata* Vahl	Moraceae	Tree	-	+	+	-
45	*Ficus sur* Forssk.	Moraceae	Tree	+	-	-	-
46	*Funtumia elastica* (Preuss) Stapf.	Apocynaceae	Tree	+	+	-	-
47	*Gliricidia sepium* (Jacq.) Walp.	Papilionaceae	Tree	+	+	+	+
48	*Gloriosa superba* L.	Colchicaceae	Climber	+	-	+	-
49	*Glyphaea brevis* (Spreng.) Monachino	Tiliaceae	Shrub	-	-	+	+
50	*Grewia mollis* Juss.	Tiliaceae	Shrub	+	+	-	-
51	*Hewittia sublobata* (L. f.) Kuntze.	Convolvulaceae	Climber	+	-	+	-
52	*Hibiscus asper* Hook.f.	Malvaceae	Herb	-	-	+	-
53	*Hippocratea pallens* Planch. Ex Oliv.	Celastraceae	Climber	+	-	-	+

54	*Holarrhena floribunda* (G. Don et Schinz) T. Durand et Schinz	Apocynaceae	Tree	-	+	-	-
55	*Hoslundia opposita* Vahl	Lamiaceae	Climber	-	-	-	+
56	*Ipomea involucrata* P. Beauv.	Convolvulaceae	Herb	-	-	+	+
57	*Ipomea nil* (L.) Roth	Convolvulaceae	Herb	-	-	+	+
58	*Jatropha gossypifolia* L.	Euphorbiaceae	Shrub	-	-	+	+
59	*Lecaniodiscus cupanioides* Planch. Ex Benth.	Sapindaceae	Tree	+	+	-	-
60	*Leucaena leucocephala* (Lam.) de Wit	Mimosaceae	Tree	+	-	-	-
61	*Malacantha alnifolia* (Baker) Pierre	Sapotaceae	Tree	-	+	-	-
62	*Mallotus oppositifolius* (Geiseler) Mill. Arg.	Euphorbiaceae	Shrub	-	+	-	-
63	*Manihot esculenta* Crantz.	Euphorbiaceae	Shrub	+	-	+	+
64	*Margaritaria discoidea* (Ba ll.) Webster	Euphorbiaceae	Tree	-	-	+	-
65	*Melenthera scandens* (Schumach. et Thonn.) Roberty	Asteraceae	Herb	-	-	-	+
66	*Merremia sp* B.	Convolvulaceae	Climber	+	-	-	-
67	*Microdesmis puberula* Hook.f. ex Planch.	Pandaceae	Herb	+	-	-	-
68	*Milletia thonningii* (Schum. et Thonn.) Baker	Papilionaceae	Tree	+	-	-	-
69	*Momordica charantia* L.	Cucurbitaceae	Climber	-	-	+	-
70	*Momordica foetida* Schum. & Thonn.	Cucurbitaceae	Herb	-	-	-	+
71	*Mucuna sloanei* Fawcett & Rendle	Fabaceae	Climber	-	-	+	+
72	*Mucuna sp* Adans	Papilionaceae	Climber	-	+	-	-
73	*Musa sapientum* L.	Musaceae	Shrub	-	+	-	+
74	*Musa sp* L.	Musaceae	Shrub	+	-	-	-
75	*Myrianthus arboreus* P. Beauv.	Moraceae	Tree	+	-	-	+
76	*Newbouldia laevis* (P. Beauv.) Seem. ex Bureau.	Bignoniaceae	Tree	+	-	-	-

77	*Oxytenanthera abyssinica* (A. Rich.) Munro	Poaceae	Shrub	-	+	-	-
78	*Parquetina nigrescens* (Afzel.) Bullock	Periplocaceae	Climber	-	+	-	-
79	*Passiflora foetida* Mast.	Passifloraceae	Climber	-	-	-	+
80	*Paullinia pinnata* L.	Sapindaceae	Climber	+	+	-	-
81	*Pentaclethra macrophylla* Benth.	Mimosaceae	Tree	+	-	-	-
82	*Pergularia daemia* (Forssk.) Choiv.	Asclepiadaceae	Climber	+	-	-	-
83	*Phaulopsis falcisepala* C.B. Clarke	Acanthaceae	Herb	+	-	-	-
84	*Platostoma africanum* P. Beauv.	Lamiaceae	Herb	-	-	+	-
85	*Pouzolzia guineensis* Benth.	Urticaceae	Herb	+	-	+	+
86	*Raphia hookeri* G. Mann & H. Wendl.	Arecaceae	Shrub	-	+	-	-
87	*Rauvolfia vomitoria* Afzel.	Apocynaceae	Tree	+	+	+	+
88	*Ricinodendron heudelotii* (Baill.) Pierre ex Pax.	Euphorbiaceae	Tree	-	+	-	-
89	*Rothmania longiflora* Salisb.	Rubiaceae	Shrub	+	-	-	-
90	*Securinega virosa* (Roxb. ex W lld.) Ba ll.	Euphorbiaceae	Shrub	-	+	+	-
91	*Senna hirsuta* L.	Caesalpiniaceae	Shrub	-	+	-	-
92	*Sida acuta* Burm.f.	Malvaceae	Shrub	-	-	+	-
93	*Sida corymbia* RE Fries	Malvaceae	Herb	-	-	-	+
94	*Sida urens* L.	Malvaceae	Herb	-	-	+	+
95	*Smilax kraussiana* Meisn.	Smilacaceae	Climber	+	+	-	-
96	*Solenostemon monostachyus* (P Beauv.) Briq.	Lamiaceae	Herb	-	-	+	-
97	*Spathodea campanulata* P. Beauv.	Bignoniaceae	Tree	+	-	-	-
98	*Spondias monbin* L.	Anacardiaceae	Tree	+	+	+	+
99	*Stachytarpheta cayennensis* (Rich.) Schau.	Verbenaceae	Herb	-	+	+	+
100	*Sterculia tragacantha* Lindl.	Sterculiaceae	Tree	+	+	-	-
101	*Syndrella nodiflora* (L.) Gaertn.	Asteraceae	Herb	+	-	+	+
102	*Talinum triangulare* (Jacq.) Willd	Portulacaceae	Herb	-	-	+	-

103	*Telfairia occidentalis* Hook F.	Cucurbitaceae	Climber	-	-	+	+
104	*Urena lobata* L.	Malvaceae	Shrub	-	-	-	+
105	*Voacanga africana* Stapf.	Apocynaceae	Tree	+	-	-	-
106	*Xanthosoma esculenta* (L.) Schott	Araceae	Herb	-	-	+	+

A, B, C, and D represent the four plots randomly selected in the Tree fallow physiognomy

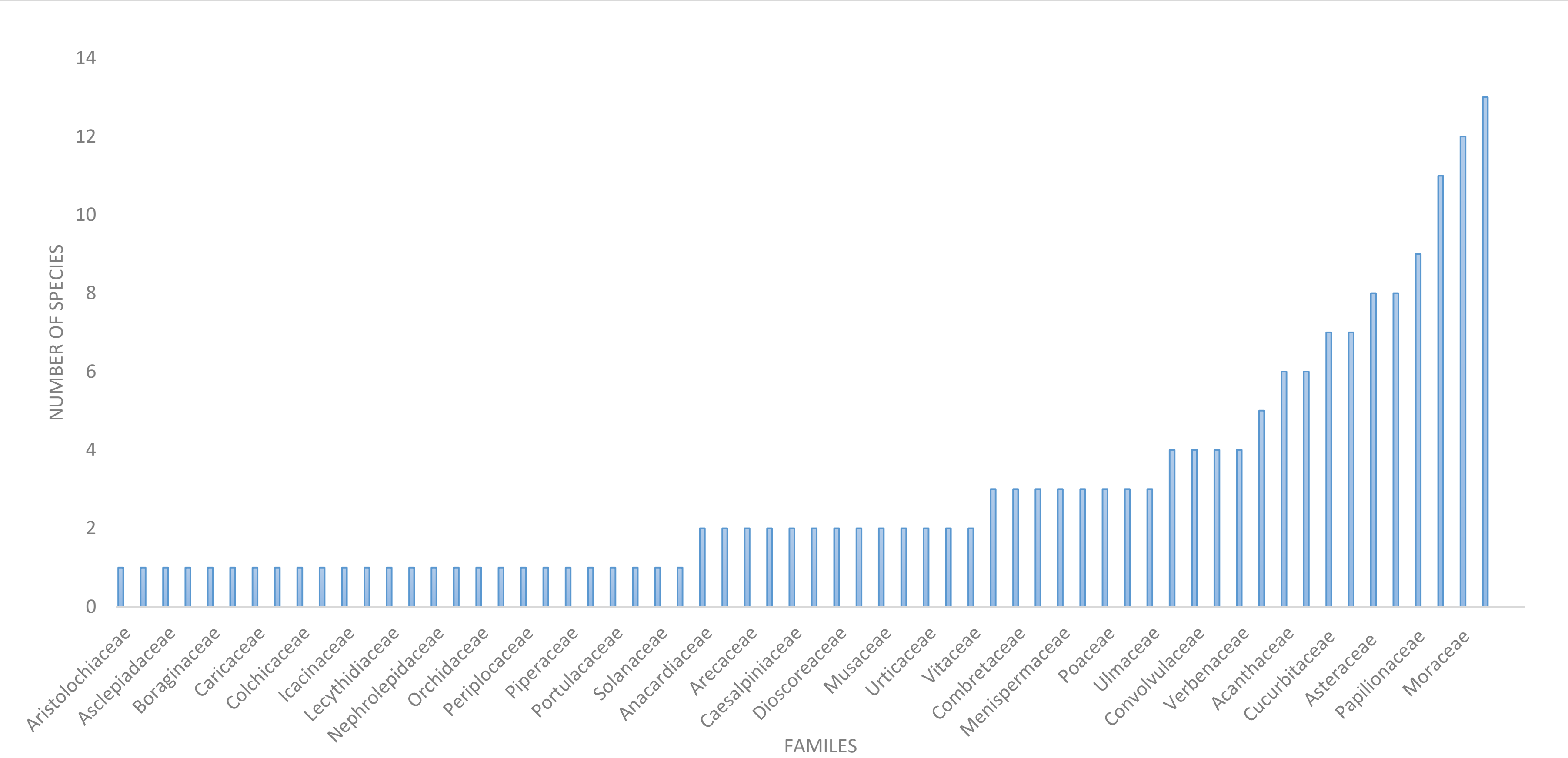

Figure 4.1: Plant family dominance of species in all the three physiognomies

4.1.2 Woody species

A total of ninety-nine (99) woody species were encountered in all the three physiognomies studied accounting for 51.8% of the whole flora of the vegetation in Ibodi Monkey forest (Table 4.4). In RF, fifty-seven (57) woody species (13 shrubs and 44 trees) were encountered, forty (40) woody species (11 shrubs and 29 trees) in the CP and fifty (50) woody species (20 shrubs and 30 Trees) in the TF (Table 4.4). Twelve (12) woody species including *Albizia zygia, Alchornea laxiflora Anchomanes difformis, Antiaris toxicaria, Cnestis ferruginea, Elaeis guineensis, Ficus exasperata, Lecaniodiscus cupanioides, Newbouldia laevis, Oxytenanthera abyssinica, Sterculia tragacantha, Voacanga africana* were shared in the three physiognomies of study area (Table 4.4). Seventeen (17) woody species are common to the RF and CP and they include *Albizia zygia, Alch ornea laxiflora, Anchomanes difformis, Antiaris toxicaria, Cnestis ferruginea, Cola mi llenii, Elaeis guineensis, Ficus exasperata, Lecaniodiscus cupanioides, Morinda lucid a, Morus mesozygia, Newbouldia laevis, Oxytenanthera abyssinica, Psychotria* Sp*, Ste rculia tragacantha, Trilepisium madagascariensis, Voacanga africana* (Table 4.4) Tw enty-

one (21) Species are common to the RF and TF they include *Albizia zygia, Alchornea cordifolia, Alchornea laxiflora, Anchomanes difformis, Antiaris toxicaria, Baphia niti da, Cnestis ferruginea, Dalbergiella welwitschii, Elaeis guineensis, Ficus,Ficus exasp erata, Funtumia elastic, Grewia mollis, Lecaniodiscus cupanioides, Myrianthus arbor eus, Newbouldia laevis, Oxytenanthera abyssinica, Pentaclethra macrophylla, Ricino dendron heudelotii, Sterculia tragacantha* and *Voacanga africana*. Species common t o CP and TF were twenty-two (22) and they include *Albizia zygia, Alchornea laxiflora, Anchomanes difformis, Antiaris africana, Antiaris toxicaria, Cnestis ferruginea, Elaeis guineensis, Ficus exasperata, Ficus sur, Glyphaea brevis, Holarrhena floribunda, Lecaniodiscus cupanioides, Leucaena leucocephala, Mallotus oppositifolius, Newbouldia laevis, Oxytenanthera abyssinica, Rauvolfia vomitoria, Senna hirsute, Spathodea campanulata, Spondias mombin, Sterculia tragacantha* and *Voacanga africana*.

Table 4.4 – Woody Species encountered in the three physiognomies of the monkey forest Ibodi, Osun State.

S/N	NAME	FAMILY	PHYSIOGNOMIES		
			RF	CP	TF
1	*Agelaea obliqua*	Connaraceae	-	+	-
2	*Albizia ferruginea*	Mimosaceae	-	+	-
3	*Albizia zygia*	Mimosaceae	+	+	+
4	*Alchornea cordifolia*	Euphorbiaceae	+	-	+
5	*Alchornea laxiflora*	Euphorbiaceae	+	+	+
6	*Allophylus aficanus*	Sapindaceae	-	+	-
7	*Alstonia boonei*	Apocynaceae	+	-	-
8	*Anacardium occidentale*	Anacardiaceae	-	-	+
9	*Anchomanes difformis*	Araceae	+	+	+
10	*Antiaris africana*	Moraceae	-	+	+
11	*Antiaris toxicaria*	Moraceae	+	+	+
12	*Baphia nitida*	Papilionaceae	+	-	+
13	*Blighia sapida*	Sapindaceae	-	-	+
14	*Bridelia ferruginea*	Euphorbiaceae	-	-	+
15	*Calopogonium mucunoides*	Papilionaceae	-	-	+
16	*Canthium sp*	Rubiaceae	+	-	-
17	*Carica papaya*	Caricaceae	-	+	-
18	*Carpolobia lutea*	Polygalaceae	+	-	-
19	*Ceiba pentandra*	Baombacaceae	+	-	-
20	*Celtis mildbraedii*	Ulmaceae	+	-	-
21	*Celtis sp*	Ulmaceae	+	-	-
22	*Chassalia Kolly*	Rubiaceae	-	-	+
23	*Chrysophyllum albidium*	Sapotaceae	+	-	-
24	*Citrus sinensis*	Rutaceae	-	-	+
25	*Cnestis ferruginea*	Connaraceae	+	+	+
26	*Cola millenii*	Sterculiaceae	+	+	
27	*Cordia sp*	Boraginaceae	+	-	-
28	*Costus afer*	Costaceae	-	+	-
29	*Dalbergiella welwitschii*	Papilionaceae	+	-	+

30	*Deinbollia pinnata*	Sapindaceae	+	-	-
31	*Diospyros barteri*	Ebenaceae	+	-	-
32	*Diospyros sp*	Ebenaceae	+	-	-
33	*Dracaenea manii*	Dracaenaceae	+	-	-
34	*Elaeis guineensis*	Arecaceae	+	+	+
35	*Enathia chlorantha*	Annonaceae	+	-	-
36	*Ficus asperifolia*	Moraceae	+	-	+
37	*Ficus exasperata*	Moraceae	+	+	+
38	*Ficus lutea*	Moraceae	-	+	-
39	*Ficus mucuso*	Moraceae	-	+	-
40	*Ficus sp*	Moraceae	+	-	-
41	*Ficus sur* Forssk.	Moraceae	-	+	+
42	*Funtumia elastica*	Apocynaceae	+	-	+
43	*Gliricidia sepium*	Papilionaceae	-	-	+
44	*Glyphaea brevis*	Tiliaceae	-	+	+
45	*Grewia mollis*	Tiliaceae	+	-	+
46	*Holarrhena floribunda*	Apocynaceae	-	+	+
47	*Hoslundia opposita*	Lamiaceae	-	+	-
48	*Hura crepitans*	Euphorbiaceae	+	-	-
49	*Jatropha gossypifolia*	Euphorbiaceae	-	-	+
50	*Khaya grandifoliola*	Meliaceae	+	-	-
51	*Lecaniodiscus cupanioides*	Sapindaceae	+	+	+
52	*Leucaena leucocephala*	Mimosaceae	-	+	+
53	*Macaranga barteri*	Euphorbiaceae	+	-	-
54	*Malacantha alnifolia*	Sapotaceae	-	-	+
55	*Mallotus oppositifolius*	Euphorbiaceae	-	+	+
56	*Manihot esculenta*	Euphorbiaceae	-	-	+
57	*Margaritaria discoidea*	Euphorbiaceae	-	-	+
58	*Milicia excelsa*	Moraceae	-	+	-
59	*Milletia thonningii*	Papilionaceae	-	-	+
60	*Monodora myristica*	Annonaceae	+	-	-
61	*Morinda lucida*	Rubiaceae	+	+	-
62	*Morus mesozygia*	Moraceae	+	+	-

63	*Musa sapientum*	Musaceae	-	-	+
64	*Musa spp*	Musaceae	-	-	+
65	*Myrianthus arboreus*	Moraceae	+	-	+
66	*Napoleonaea vogelii*	Lecythidiaceae	+	-	-
67	*Newbouldia laevis*	Bignoniaceae	+	+	+
68	*Oxytenanthera abyssinica*	Poaceae	+	+	+
69	*Pentaclethra macrophylla*	Mimosaceae	+	-	+
70	*Psychotria sp*	Rubiaceae	+	+	-
71	*Pterygota macrocarpa*	Sterculiaceae	+	-	-
72	*Pterygota sp*	Sterculiaceae	+	-	-
73	*Raphia hookeri*	Arecaceae	-	-	+
74	*Rauvolfia vomitoria*	Apocynaceae	-	+	+
75	*Ricinodendron heudelotii*	Euphorbiaceae	+	-	+
76	*Rothmania hispida*	Rubiaceae	+	-	-
77	*Rothmania longiflora*	Rubiaceae	-	-	+
78	*Securinega virosa*	Euphorbiaceae	-	-	+
79	*Senna hirsuta*	Caesalpiniaceae	-	+	+
80	*Sida acuta*	Malvaceae	-	-	+
81	*Spathodea campanulata*	Bignoniaceae	-	+	+
82	*Sphenocentrum jollyanum*	Menispermaceae	+	-	-
83	*Spondias mombin*	Anacardiaceae	-	+	+
84	*Sterculia rhinopetala*	Sterculiaceae	+	-	-
85	*Sterculia tragacantha*	Sterculiaceae	+	+	+
86	*Strombosia pustulata*	Olacaceae	+	-	-
87	*Tabernaemontana pachysiphon*	Apocynaceae	+	-	-
88	*Tetrapleura tetraptera*	Mimosaceae	+	-	-
89	*Theobroma cacao*	Sterculiaceae	-	+	-
90	*Trema orientalis*	Ulmaceae	-	+	-
91	*Trichilia monedelpha*	Meliaceae	+	-	-
92	*Trichilia prieuriana*	Meliaceae	+	-	-
93	*Trilepisium madagascariensis*	Moraceae	+	+	-
94	*Triplochiton scleroxylon*	Sterculiaceae	+	-	-
95	*Urena lobata*	Malvaceae	-	-	+

96	*Vitex doniana*	Verbenaceae	-	+	-
97	*Vitex rivularis*	Verbenaceae	-	+	-
98	*Voacanga africana*	Apocynaceae	+	+	+
99	*Zanthoxyllum sp*	Rutaceae	+	-	-

RF – Regrowth forest Physiognomy

CP – Cocoa Plantation Physiognomy

TF – Tree fallow Physiognomy

4.1.3 **Herbaceous species**

In all the three physiognomies, forty-five (45) herbaceous species were encountered which accounted for 23.6 % of the whole flora encountered in the forest (Table 4.5). Eleven (11) herbaceous species were encountered in the RF, twenty-three (23) species in the in the CP and thirty-two (32) species in the TF.

Five (5) Herbaceous species were common to the three physiognomies and they included *Chromolaena odorata, Cyathula prostata, Melenthera scandens, Phaulopsis falcisepala, Pouzolzia guineensis.* Herbaceous species common to RF and CP were nine (9) and they included *Acanthus montanus, Chassalia kolly, Chromolaena odorata, Cyathula prostata, Icacina trichanta, Melenthera scandens, Phaulopsis falcisepala, Pouzolzia guineensis* and *Tacca leontopentaloides*. Furthermore, six (6) herbaceous species were common to RF and TF and they include *Chromolaena odorata*, *Cyathula prostata*, *Melenthera scandens, Microdesmis puberula, Phaulopsis falcisepala, Pouzolzia guineensis*. Lastly, there were nine (9) species common to the CP and TF and they included *Aspilia africana, Asystasia vogeliana, Chromolaena odorata, Cyathula prostata, Melenthera scandens, Phaulopsis falcisepala, Pouzolzia guineensis, Syndrella nodiflora, Xanthosoma esculenta.*

Table 4.5 – Herbaceous Species encountered in the three physiognomies of the monkey forest Ibodi, Osun State.

S/N	NAME	FAMILY	PHYSIOGOMIES		
			RF	CP	TF
1	*Abelmoschus esulentus*	Malvaceae	-	-	+
2	*Acanthus montanus*	Acanthaceae	+	+	-
3	*Ageratum conyzoides*	Asteraceae	-	-	+
4	*Ananas comosus*	Bromeliaceae	-	-	+
5	*Aspilia africana*	Asteraceae	-	+	+
6	*Asystasia gangetica*	Acanthaceae	-		+
7	*Asystasia vogeliana*	Acanthaceae	-	+	+
8	*Bidens pilosa*	Asteraceae	-	+	-
9	*Borreria ocymoides*	Rubiaceae	-	+	-
10	*Caladium bicolor*	Araceae	-	-	+
11	*Capsicum annuum*	Solanaceae	-	-	+
12	*Chassalia kolly*	Rubiaceae	+	+	-
13	*Chromolaena odorata*	Asteraceae	+	+	+
14	*Clitoria ternatea*	Fabaceae	-	-	+
15	*Commelina benghalensis*	Commelinaceae	-	+	-
16	*Commelina diffusa*	Commelinaceae	-	+	-
17	*Crochorus olitorius*	Tiliaceae	-	-	+
18	*Cucurbita moschata*	Cucurbitaceae	-	-	+
19	*Cyathula prostata*	Amaranthaceae	+	+	+
20	*Dissotis erecta*	Melastomataceae	-	-	+
21	*Eclipta prostata*	Asteraceae	-	-	+
22	*Elytraria marginata*	Acanthaceae	-	+	-
23	*Hibiscus asper*	Malvaceae	-	-	+
24	*Hypoestes* sp.	Acanthaceae	-	+	-
25	*Icacina trichanta*	Icacinaceae	+	+	-
26	*Ipomea involucrata*	Convolvulaceae	-	-	+
27	*Ipomea nil*	Convolvulaceae	-	-	+
28	*Laportea aestuans*	Urticaceae	-	+	-
29	*Melenthera scandens*	Asteraceae	+	+	+

30	*Microdesmis puberula*	Pandaceae	+	-	+
31	*Momordica foetida*	Cucurbitaceae	-	-	+
32	*Phaulopsis falcisepala*	Acanthaceae	+	+	+
33	*Phycanthus niruri*	Euphorbiaceae	-	+	-
34	*Phytolacca dodecandra*	Phytolacaceae	+	-	-
35	*Platostoma africanum*	Lamiaceae	-	-	+
36	*Pouzolzia guineensis*	Urticaceae	+	+	+
37	*Sida corymbia*	Malvaceae	-	-	+
38	*Sida urens*	Malvaceae	-	-	+
39	*Solenostemon monostachyus*	Lamiaceae	-	-	+
40	*Stachytarpheta cayennensis*	Verbenaceae	-	-	+
41	*Struchium spaganophorum*	Asteraceae	-	+	-
42	*Syndrella nodiflora*	Asteraceae	-	+	+
43	*Tacca leontopentaloides*	Taccaceae	+	+	-
44	*Talinum triangulare*	Portulacaceae	-	-	+
45	*Xanthosoma esculenta*	Araceae	-	+	+

RF – Regrowth Forest

CP – Cocoa Plantation

TF – Tree Fallow

4.1.4 Climbers, Epiphytes, ferns and Grass species

There were forty-eight (48) species in this group and they accounted for 25.1 % of the whole flora encountered in the vegetation (Table 4.6). There were nineteen (19) species in the RF, twenty-three (23) species in CP and twenty-five (25) species in TF. Three (3) species were common to all the three physiognomies and they include *Cardiospermum grandiflorum, Cissus arguta, Combretum hispidum, Dioscorea bulbifera.* Furthermore, Seven (7) species were common to the RF and CP, the species are *Cardiospermum grandiflorum, Cissus arguta, Combretum hispidum, Dioscorea bulbifera, Jateorhiza macrantha, Mezoneuron benthanianum, Mucuna pruriens.* Also, there were nine (9) species that were common to the RF and TF and they included *Cardiospermum grandiflorum, Cissus arguta, Combretum hispidum, Combretum paniculatum, Combretum sp, Dioscorea bulbifera, Hippocratea pallens, Parquetina nigrescens, Smilax kraussiana*. Lastly, there were eight (8) species common to the CP and TF, they included *Cardiospermum grandiflorum, Cissus arguta, Combretum hispidum, Dioscorea bulbifera, Gloriosa superba, Momordica charantia, Mucuna sloanei, Paullinia pinnata.*

Table 4.6: Climbers, Epiphytic, Fern and Grass Species encountered in the three physiognomies of the monkey forest Ibodi, Osun State.

S/N	NAME	FAMILY	HERB	PHYSIOGNOMIES RF	CP	TF
1	*Adenia cissampeloides*	Passifloraceae	Climber	+	-	-
2	*Adenia lobata*	Passifloraceae	Climber	-	+	-
3	*Aerangis biloba*	Orchidaceae	Epiphyte	-	+	-
4	*Alafia barteri*	Apocynaceae	Climber	+	-	-
5	*Aristolochia ringens*	Aristolochiaceae	Climber	-	-	+
6	*Axonopus compressus*	Poaceae	Grass	-	-	+
7	*Baissea axillaris*	Apocynaceae	Climber	+	-	-
8	*Byrsocarpus coccineus*	Connaraceae	Climber	-	-	+
9	*Cardiospermum grandiflorum*	Sapindaceae	Climber	+	+	+
10	*Centosema pubescens*	Papilionaceae	Climber	-	-	+
11	*Cissampelos owariensis*	Menispermaceae	Climber	-	+	-
12	*Cissus arguta*	Vitaceae	Climber	+	+	+
13	*Cissus quadrangularis*	Vitaceae	Climber	+	-	-
14	*Clerodendrom volubile*	Verbenaceae	Climber	-	+	-
15	*Combretum hispidum*	Combretaceae	Climber	+	+	+
16	*Combretum paniculatum*	Combretaceae	Climber	+	-	+
17	*Combretum sp*	Combretaceae	Climber	+	-	+
18	*Desmodium scorpiurus*	Papilionaceae	Climber	-	+	-
19	*Dioscorea bulbifera*	Dioscoreaceae	Climber	+	+	+
20	*Dioscorea dumetorum*	Dioscoreaceae	Climber	-	-	+
21	*Ficus asperifolia*	Moraceae	Climber	-	-	+
22	*Gloriosa superba*	Colchicaceae	Climber	-	+	+
23	*Hewittia sublobata*	Convolvulaceae	Climber	-	-	+
24	*Hippocratea pallens*	Celastraceae	Climber	+	-	+
25	*Hoslundia opposita*	Lamiaceae	Climber	-	-	+
26	*Jateorhiza macrantha*	Menispermaceae	Climber	+	+	-
27	*Landolphia owarrensis*	Apocynaceae	Climber	+	-	-
28	*Luffa acutangula*	Cucurbitaceae	Climber	-	+	-
29	*Merremia sp*	Convolvulaceae	Climber	-	-	-
30	*Mezoneuron benthanianum*	Caesalpiniaceae	Climber	+	+	-

31	*Momordica charantia*	Cucurbitaceae	Climber	-	+	+
32	*Momordica cissoides*	Cucurbitaceae	Climber	-	+	-
33	*Momordica foetida*	Cucurbitaceae	Climber	-	+	-
34	*Motandra guineensis*	Apocynaceae	Climber	+	-	-
35	*Mucuna pruriens*	Papilionaceae	Climber	+	+	-
36	*Mucuna sloanei*	Fabaceae	Climber	-	+	+
37	*Mucuna sp*	Papilionaceae	Climber	-	-	+
38	*Nephrolepis sp*	Nephrolepidaceae	Fern	-	+	-
39	*Panicum maximum*	Poaceae	Grass	-	+	-
40	*Parquetina nigrescens*	Periplocaceae	Climber	+	-	+
41	*Passiflora foetida*	Passifloraceae	Climber	-	-	+
42	*Paullinia pinnata*	Sapindaceae	Climber	-	+	+
43	*Pergularia daemia*	Asclepiadaceae	Climber	-	-	+
44	*Piper guineense*	Piperaceae	Climber	-	+	-
45	*Smilax kraussiana*	Smilacaceae	Climber	+	-	+
46	*Strophanthus sarmentosus*	Apocynaceae	Climber	+	-	-
47	*Telfairia occidentalis*	Cucurbitaceae	Climber	-	-	+
48	*Tragia benthami*	Euphorbiaceae	Climber	-	+	-

RF – Regrowth forest

CP – Cocoa Plantation

TF – Tree fallow

4.2 - TEMPORAL CHANGES IN THE FLORISTIC COMPOSITION OF IBODI MONKEY FOREST

4.2.1 **Summary of the temporal changes of Species encountered in 2013 and the present study**

In 2013, a total of one hundred and sixty-three (163) individual species were observed in all the three physiognomy, with the present study, one Hundred and ninety-one (191) individual species which amounts to 17.2% increase in the number of individual species over a five year period and an average of six (6) new individual species being introduced to the forest annually. Seventy-nine (79) species were encountered in RF in 2013 presently, there are eighty-seven (87) species which accounts for 10.1% increase in the number of new individual species found in the physiognomies. In 2013, fifity-six (56) species were recorded in CP; presently eighty-six (86) species were found accounting for 53.6% increase. Finally in the TF, eighty-two (82) species were present in 2013, presently One hundred and six (106) individual species were encountered which accounted for 29.3% increase in the number of individual species in the physiognomy. (Figure 4.2)

There was significant difference in the level or presence of species between 2013 and 2017 across the three sites. That is, the number of species varies significantly from year 2013 to 2017. A Post Hoc test was conducted in order to measure the level of species variation across the years under consideration. The Post Hoc revealed that significant variation existed in the number of woody and climber species as well as between woody and herbaceous species between 2013 and 2017. Thus, woody species and climber species in 2017 across the three sites varies significantly compared to the number of woody species observed in 2013. Similarly, woody species and herb species also significantly varied within the years. The number of woody species varied significantly from climber species from one year to the other year.

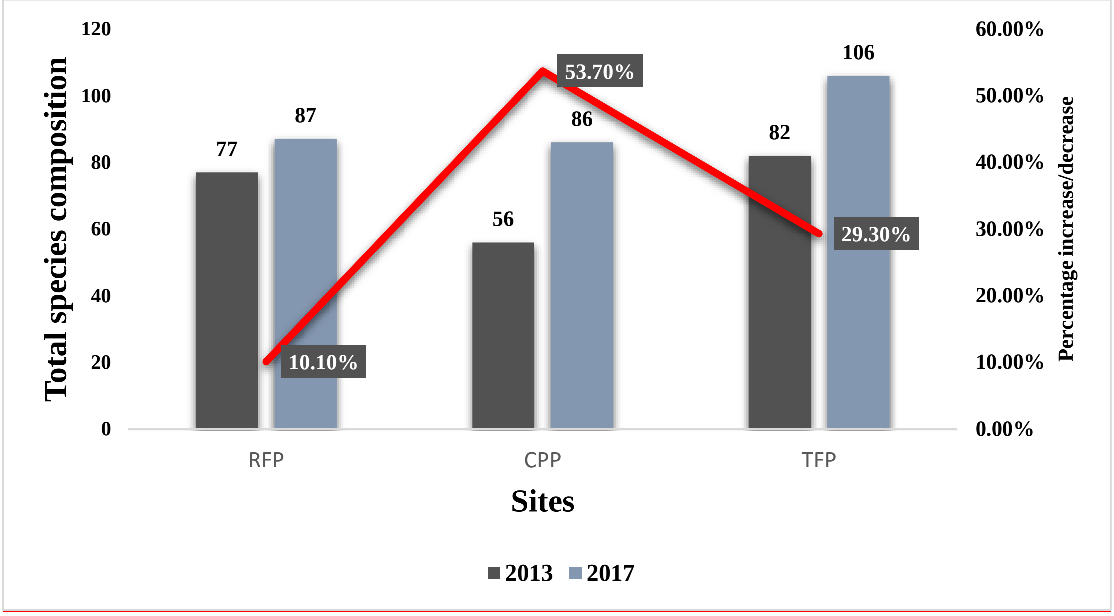

Figure 4.2: Temporal changes Summary of Species in 2013 and 2017

4.2.2 **Temporal changes in Woody species**

In 2013, a total of ninety-three (93) woody species were observed in all the three physiognomies. Presently, a total of ninety-nine (99) woody species were encountered which accounted for a 6.50% increase. In the RF in 2013, sixty (60) woody species were encountered; presently fifty-seven (57) woody species were recorded. This represents a 5% decrease in the number of species in the physiognomy. In the CP in 2013, there were twenty-six (26) woody species. Presently, there are forty (40) woody species representing 53.80% increase. Furthermore, in 2013 there were fourty-one (41) woody species in the TF; presently fifty (50) woody species were found which accounted f or an increase of 22% number of species recorded within 5 years (Figure 4.3)

The number of woody species common to the three physiognomies increased from four (4) species in 2013 to twelve (12) now. *Albizia zygia* and *Elaeis guineensis* were common to all the physiognomies in the two studies. Furthermore, the number of woody species common to the RF and CP in 2013 increased from fourteen (14) to seventeen (17), in the present study. *Albizia zygia*, *Antiaris toxicaria*, *Elaeis guineensis*, *Ficus exasperata*, *Lecaniodiscus cupanioides*, *Voacanga africana* were common to both studies in the two physiognomies. In RF and TF in 2013, the number of species common to both physiognomies increased from seven (7) in 2013 to Twenty-one (21) in the present study. *Albizia zygia*, *Elaeis guineensis*, *Ficus exasperata* were common to the two studies and physiognomies. Lastly, species commom to CP and TF increased from sixteen (16) in 2013 to twenty-two (22) in the present study. The species common in both studies in both physiognomies included *Albizia zygia, Alchornea laxiflora, Cnestis ferruginea, Elaeis guineensis, Ficus exasperata, Holarrhena floribunda, Newb ouldia laevis, and Rauvolfia vomitoria.*

4.2.3 **Temporal changes in herbaceous species**

In 2013, a total of thirty-three (33) herbaceous species were reported in all the three physiognomies. In the present study, a total of forty-five (45) herbaceous species were encountered which accounts for an increase of 36.40%. In the RF in 2013, six (6) herbaceous species were encountered. In the present study, eleven (11) herbaceous species were recorded. This represents 83.30% increase in the number of herbaceous species in the physiognomy. This suggests that the number of existing herbaceous species may have increased or new herbaceous species invaded the physiognomy in the past 5 years. In the CP in 2013, there were seventeen (17) species. In the present study, there were twenty-three (23) species representing 35.30% increase. Furthermore, there were nineteen (19) species in the TF in 2013 but in the present study, thirty-two (32) species were recorded accounting for 68.40% increase within 5 years. (Figure 4.3)

The number of species common to the three physiognomies increased from two (2) species in 2013, In the present study twelve (5) species were observed. *Chromolaena odorata* was common to all the physiognomies in the two studies. Furthermore, the number of herbaceous species common to the RF and CP in 2013 increased from three (3) to nine (9) in the present study. *Chromolaena odorata* was common to both studies in the two physiognomies. In RF and TF in 2013, the number of species common to both physiognomies increased from three (3) to six (6) in the current study. *Chromolaena odorata* was common to the two studies and physiognomies.

Lastly, species common to CP and TF increased from five (5) in 2013 to nine (9) in the present study. The species common in both study in both physiognomies was *Chromolaena odorata*

4.2.4 **Temporal changes in Climbers, Epiphytes, ferns and Grass species**

In 2013, a total of thirty-seven (37) species were reported in all the three physiognomies. In the present study, a total of forty-eight (48) species were encountered which accounted for a 29.70% increase. In the RF in 2013, eleven (11) species were encountered n the present study, nineteen (19) species were seen. This represents a 72.70% increase in the number of species in this in the physiognomy and an avearge of two new species invading the physiognomy in the past 5 years. In the CP in 2013, there were twelve (12) species. Presently, there are twenty-three (23) species representing 91.70% increase. Furthermore, there were twenty (20) species in the TF in 2013, presently twenty-five (25) species were seen accounting to 25% increase of new species observed within 5 years. None of the species in these group were common to the three physiognomies in 2013, Three (3) species were common to all the three physiognomies and they included *Cardiospermum grandiflorum, Cissus arguta, Combretum hispidum, Dioscorea bulbifera.* None of the species was common to all the physiognomies in the two studies. Furthermore, the number of herbaceous species common to the RF and CP in 2013 increased from one (1) to seven (7) in the present study.

None of the species was common to both studies in the two physiognomies. In RF and TF in 2013, the number of species common to both physiognomies increased from one (1) in 2013 to six (9) in the current study. None of the species was common to the two studies and physiognomies. Lastly, species common to CP and TF increased from six (6) in 2013 to eight (8) in the present study. The species common in both study in both physiognomies was *Paullinia pinnata*. (Figure 4.3)

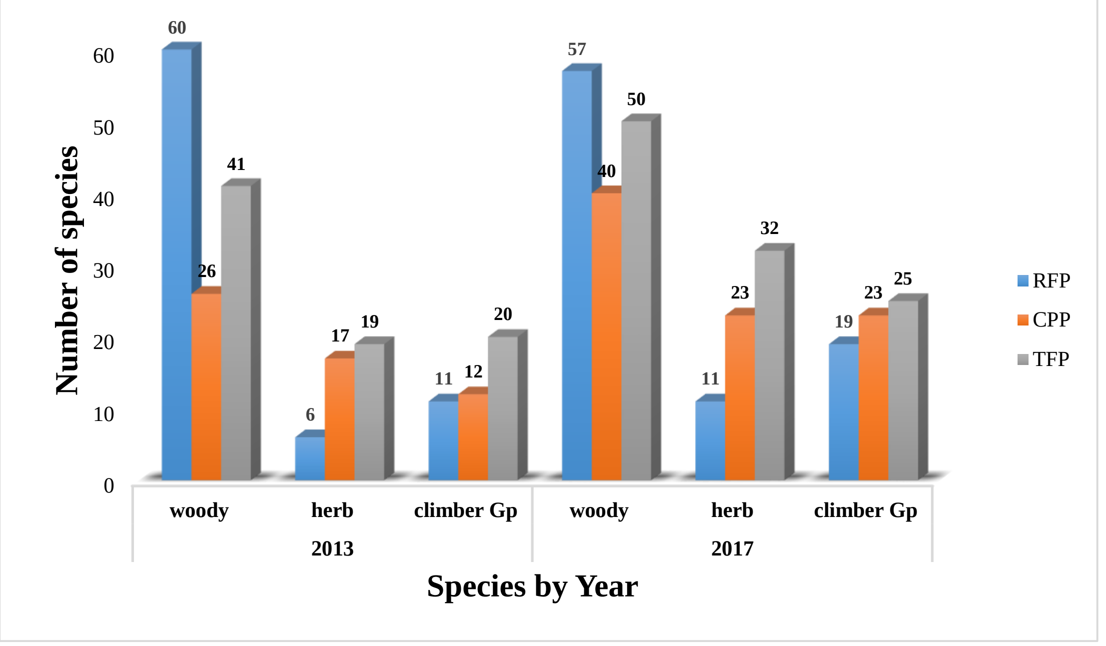

Figure 4.3: Temporal changes in the different group of species in the study area

4.3 - VEGETATION STRUCTURE

4.3.1 Tree Species Classification and Biodiversity Indices

Shannon-Wiener diversity index of the three physiognomies ranges from 0.29 to 3.02 the highest species diversity index in the RF and lowest in the TF. Furthermore, plant species richness index shows that the RF had the highest species richness of 8.83 followed by CP with 1.38 and TF with the lowest richness of 0.83. The species evenness was in the order RF (0.843) > TF (0.266) > CP (0.240) (Table 4.7)

Table 4.7: Margalef, Shannon-Wiener and Evenness Indices in the three Physiognomies of the study area

Physiognomies	R	H'	E
RF	8.83	3.02	0.84
CP	1.38	0.39	0.24
TF	0.83	0.29	0.27

R - Margalef's Species Richness

H' - Shannon-Wiener Species diversity index

E - Shannon's equitability Evenness

The evaluation of similarity index for all the three physiognomies using Sorensen index of similarity showed low similarity within the three physiognomies (similarities less than 50% in all the comparison made) with CP and TF being the most similar with a similarity index of 48.90%. The similarity between RF and TF was 39.30%. RF and CP and RF had the least similarity index value at 35.10%. (Table 4.8)

Table 4.8: Sorensen's index (%) of similarity of the three Physiognomies of the study area.

Physiognomies	RF	CP	TF
RF	**-**		
CP	35.10	**-**	
TF	39.30	48.90	**-**

RF – Regrowth forest

CP – Cocoa Plantation

TF – Tree fallow

4.3.2 – **Woody species density**

A total of 952 individuals per hectare were encountered in the three physiognomies. Mean Density of woody species per hectare in the three physiognomies is presented in Table 4.9.

The highest species density in the three physiognomies was in the RF with 484 individuals per hectare while the TF has the lowest density of woody species with 176 individuals p er hectare. The CP has an intermediate value of 292 individual woody species per hect are. The dominant species in terms of density in RF were *Trichilia prieureana,* (92 spe cies per hectare), *Lecaniodiscus cupanioides,* (60 species per hectare) and *Diospyros* s p (56 species per hectare). Furthermore, in the CP only one species was dominant whic h is *Theobroma cacao* with 268 species per hectare which accounted for about 91.8% of the total density of the physiognomy. In TF, dominant species in terms of density w as *Gliricidia sepium* with 164 individuals per hectare which accounted for 93.2% of th e total density.

Alstonia boonei and 15 other species in the RF have the lowest density of 4 stems per h ectare while other species had intermediate values. In the CP, *Albizia ferruginea, Vitex doniana,* and *Voacanga africana* had the lowest density of 4 stems per hectare while o ther species had intermediate values. In TF, *Ricinodendron heudelotii* had the lowest d ensity of four stems per hectare while the other species in the physiognomy had interm ediate values.

Table 4.9: Mean Density of woody species (per Hectare) in the three physiognomies i n the study area

S/N	NAME	FAMILY	PHYSIOGNOMIES		
			RF	CP	TF
1	*Albizia ferruginea*	Mimosaceae	-	4	-
2	*Albizia zygia*	Mimosaceae	12	-	-
3	*Alchornea cordifolia*	Euphorbiaceae	8	-	-
4	*Alstonia boonei*	Apocynaceae	4	-	-
5	*Baphia nitida*	Papilionaceae	24	-	-
6	*Canthium sp*	Rubiaceae	4	-	-
7	*Carpolobia lutea*	Polygalaceae	4	-	-
8	*Ceiba pentandra*	Baombacaceae	4	-	-
9	*Celtis sp*	Ulmaceae	4	-	-
10	*Chrysophyllum albidium*	Sapotaceae	8	-	-
11	*Citrus sinensis*	Rutaceae	-	-	4
12	*Cola millenii*	Sterculiaceae	8	-	-
13	*Cordia sp*	Boraginaceae	4	-	-
14	*Deinbollia pinnata*	Sapindaceae	4	-	-
15	*Diospyros barteri*	Ebenaceae	8	-	-
16	*Diospyros sp*	Ebenaceae	56	-	-
17	*Dracaenea manii*	Dracaenaceae	8	-	-
18	*Elaeis guineensis*	Arecaceae	8	12	-
19	*Gliricidia sepium*	Papilionaceae	-	-	164
20	*Khaya grandifoliola*	Meliaceae	4	-	-
21	*Lecaniodiscus cupanioides*	Sapindaceae	60	-	-
22	*Monodora myristica*	Annonaceae	8	-	-
23	*Morinda lucida*	Rubiaceae	8	-	-
24	*Myrianthus arboreus*	Moraceae	4	-	-
25	*Napoleonaea vogelii*	Lecythidiaceae	4	-	-
26	*Newbouldia laevis*	Bignoniaceae	4	-	-
27	*Pentaclethra macrophylla*	Mimosaceae	4	-	-
28	*Pterygota macrocarpa*	Sterculiaceae	32	-	-
29	*Pterygota sp*	Sterculiaceae	12	-	-

30	*Rauvolfia vomitoria*	Apocynaceae	-	-	4
31	*Sterculia rhinopetala*	Sterculiaceae	4	-	-
32	*Sterculia tragacantha*	Sterculiaceae	4	-	-
33	*Strombosia pustulata*	Olacaceae	8	-	-
34	*Tabernaemontana pachysiphon*	Apocynaceae	16	-	-
35	*Theobroma cacao*	Sterculiaceae	-	268	-
36	*Trichilia monedelpha*	Meliaceae	8	-	-
37	*Trichilia prieuriana*	Meliaceae	92	-	-
38	*Trilepisium madagascariensis*	Moraceae	12	-	-
39	*Triplochiton scleroxylon*	Sterculiaceae	4	-	-
40	*Vitex doniana*	Verbenaceae	-	4	-
41	*Voacanga africana*	Apocynaceae	4	4	-
42	*Zanthoxyllum sp*	Rutaceae	12	-	-
	TOTAL		484	292	176

RF – Regrowth forest

CP – Cocoa Plantation

TF – Tree fallow

4.3.3 Basal Area (m^2ha^{-1}) distribution

The RF has the highest mean basal area 17.96 (m^2ha^{-1}) while the TF has the lowest mean basal area (1.93 m^2ha^{-1}) with the CP having an intermediate mean basal area (13.12 m^2ha^{-1}) (table 4.10).

The contribution of each species to the overall basal area of each physiognomies show ed that the in the RF *Pterygota macrocarpa* contributed the largest mean basal area of 4.95 $m^2.ha^{-1}$ (27.6% of the total), *Carpolobia lutea* had the lowest mean basal area of 0.00039 $m^2.ha^{-1}$ while other species had intermediate values. In CP, *Theobroma cacao* contributed the largest mean basal area of 12.43 $m^2.ha^{-1}$ (94.8% of the total), *Voacanga africana* had the smallest mean basal area of 0.064 $m^2.ha^{-1}$ while other species had intermediate values. *Gliricidia sepium* contributed the largest mean basal area of 1.61 $m^2.ha^{-1}$ in the TF (83.60% of total basal area in the physiognomy), *Rauvolfia vomitoria* had th e smallest mean basal area of 0.0046 $m^2.ha^{-1}$ while other species had intermediate values (Table 4.10).

Table 4.10: Mean basal area of woody species ($m^2 \cdot ha^{-1}$) in the three physiognomies in Ibodi Monkey forest, Ibodi, Osun State.

			PHYSIOGNOMIES		
S/N	NAME	FAMILY	RF	CP	TF
1	*Albizia ferruginea*	Mimosaceae	-	0.010	-
2	*Albizia zygia*	Mimosaceae	0.13	-	-
3	*Alchornea cordifolia*	Euphorbiaceae	0.022	-	-
4	*Alstonia boonei*	Apocynaceae	0.014	-	-
5	*Baphia nitida*	Papilionaceae	1.13	-	-
6	*Canthium sp*	Rubiaceae	0.0035	-	-
7	*Carpolobia lutea*	Polygalaceae	0.00040	-	-
8	*Ceiba pentandra*	Baombacaceae	0.0046	-	-
9	*Celtis sp*	Ulmaceae	0.013	-	-
10	*Chrysophyllum albidium*	Sapotaceae	0.47	-	-
11	*Citrus sinensis*	Rutaceae	-	-	0.31
12	*Cola millenii*	Sterculiaceae	0.031	-	-
13	*Cordia sp*	Boraginaceae	0.77	-	-
14	*Deinbollia pinnata*	Sapindaceae	0.088	-	-
15	*Diospyros barteri*	Ebenaceae	0.014	-	-
16	*Diospyros sp*	Ebenaceae	1.64	-	-
17	*Dracaenea manii*	Dracaenaceae	0.23	-	-
18	*Elaeis guineensis*	Arecaceae	0.41	0.44	-
19	*Gliricidia sepium*	Papilionaceae	-	-	1.61
20	*Khaya grandifoliola*	Meliaceae	0.034	-	-
21	*Lecaniodiscus cupanioides*	Sapindaceae	1.93	-	-
22	*Monodora myristica*	Annonaceae	0.055	-	-
23	*Morinda lucida* Benth.	Rubiaceae	0.038	-	-
24	*Myrianthus arboreus*	Moraceae	0.075	-	-
25	*Napoleonaea vogelii*	Lecythidiaceae	0.0020	-	-
26	*Newbouldia laevis*	Bignoniaceae	0.35	-	-
27	*Pentaclethra macrophylla*	Mimosaceae	0.0046	-	-

28	*Pterygota macrocarpa*	Sterculiaceae	4.95	-	-
29	*Pterygota sp*	Sterculiaceae	0.17	-	-
30	*Rauvolfia vomitoria*	Apocynaceae	-	-	0.0046
31	*Sterculia rhinopetala*	Sterculiaceae	0.00080	-	-
32	*Sterculia tragacantha*	Sterculiaceae	0.042	-	-
33	*Strombosia pustulata*	Olacaceae	0.028	-	-
34	*Tabernaemontana pachysiphon*	Apocynaceae	0.20	-	-
35	*Theobroma cacao*	Sterculiaceae	-	12.43	-
36	*Trichilia monedelpha*	Meliaceae	0.022	-	-
37	*Trichilia prieuriana*	Meliaceae	3.48	-	-
38	*Trilepisium madagascariensis*	Moraceae	0.53	-	-
39	*Triplochiton scleroxylon*	Sterculiaceae	0.98	-	-
40	*Vitex rivularis*	Verbenaceae	-	0.080	-
41	*Voacanga africana*	Apocynaceae	0.030	0.064	-
42	*Zanthoxyllum sp*	Rutaceae	0.086	-	-
	TOTAL		17.96	13.12	1.93

RF – Regrowth forest

CP – Cocoa Plantation

TF – Tree fallow

4.3.4 Family Important Value Index (FIVI)

The family Importance Value (FIV; see Table 4.11) was used to assess the importance of different families in the study area. Family Important Value combines relative density, relative frequency and relative basal area which is the proportion of basal area of a species in the study area into a measure that can be used to indicate the ecological influence of each family in the forest.

The families with the highest FIV above the value of ten (10) were Sterculiaceae (60.65), Papilionaceae (33.09), Meliaceae (24.66), Ebenaceae (19.08), Sapindaceae (16.87), Moraceae (15.64), Euphorbiaceae (12.02), Apocynaceae (10.38). These eight (8) families accounted for 77.64% of the FIVI.

Table 4.11: Family importance value (FIV) of all families in the physiognomies in Ibodi Monkey forest, Ibodi, Osun State.

S/N	Family	RD_m	RD	RF	FIV
1	Annonaceae	0.16	0.84	2.02	3.02
2	Apocynaceae	0.96	3.36	6.06	10.38
3	Arecaceae	2.57	2.10	2.02	6.70
4	Baombacaceae	0.014	0.42	1.01	1.44
5	Bignoniaceae	1.05	0.42	2.02	3.49
6	Boraginaceae	2.32	0.42	1.01	3.75
7	Dracaenaceae	0.69	0.84	1.01	2.54
8	Ebenaceae	10.34	6.72	2.02	19.08
9	Euphorbiaceae	0.068	0.84	11.11	12.02
10	Lecythidiaceae	0.0062	0.42	1.01	1.44
11	Meliaceae	10.70	10.92	3.03	24.66
12	Mimosaceae	0.71	2.10	5.05	7.86
13	Moraceae	1.83	1.68	12.12	15.64
14	Olacaceae	0.084	0.84	1.01	1.93
15	Papilionaceae	8.29	19.75	5.05	33.08
16	Polygalaceae	0.0012	0.42	1.01	1.43
17	Rubiaceae	0.13	1.26	6.06	7.45
18	Rutaceae	1.21	1.68	2.02	4.91
19	Sapindaceae	6.10	6.72	4.04	16.87
20	Sapotaceae	1.42	0.84	2.02	4.28
21	Sterculiaceae	18.71	34.87	7.07	60.65
22	Ulmaceae	0.041	0.42	2.02	2.48
23	Verbenaceae	0.24	0.42	2.02	2.68

4.4 – TEMPORAL CHANGES IN THE FOREST STRUCTURE OF IBODI MONKEY FOREST

4.4.1 – Temporal changes in the tree Species Classification and Biodiversity Indices

In 2013, Shannon's diversity index (SDI) in RF was 3.40, the value for the present study was 3.02 which represents an 11.25% decrease in the species diversity index (table 4.12). Furthermore, in the CP, 2013 SDI was 2.50, presently the SDI value is 0.37 this represents 84.57% decrease in the SDI value in the physiognomy over a 5 year period. In the TF, SDI in 2013 was 3.24 while in present enumeration, it is 0.29 representing a 90.99% decrease in the SDI in the physiognomy.

Species richness index (SRI) shows that the RF in 2013 has a value of 15.81, the present value was 8.83 representing a 44.18% decrease. Moreover, the SRI in 2013 in CP was 10.82 while in the present study, the value is 1.38 representing an 87.27% decrease in the physiognomy. Additionally, in the TF in 2013, the SRI value was 13.57 while in the present study the value was 0.83 representing a 93.85% decrease in the physiognomy.

Species evenness index (SEI) value in the RF in 2013 was 0.93 while presently, the value is 0.84 representing a 9.45% decrease in the value in the physiognomy. Furthermore, in the CP in 2013, the SEI value was 0.80 while presently, the value is 0.24 representing a 69.96% decrease in value in the physiognomy. Moreover, in the

TF in 2013, the SEI value was 0.93 while presently, the value is 0.27 representing a 71.31% decrease in the SEI value for the physiognomy. (Table 4.12)

Table 4.12: **Temporal change in the tree species classification and biodiversity indices the physiognomies in Ibodi Monkey forest, Ibodi, Osun State.**

Physiognomies	Year	R	H'	E
RF	2013	15.81	3.40	0.93
	present study	8.83	3.02	0.84
CP	2013	10.82	2.50	0.80
	present study	1.38	0.39	0.24
TF	2013	13.57	3.24	0.93
	present study	0.83	0.29	0.27

R - Margalef's Species Richness

H' - Shannon-Wiener Species diversity index

E - Shannon's equitability Evenness

RF – Regrowth forest

CP – Cocoa Plantation

TF – Tree fallow

The evaluation of the temporal changes in Sorensen similarity index (SSI) value among the three physiognomies is highlighted below. In 2013, SSI value showed the low similarity between all the physiognomies with CP and TF being the most similar with SSI value of 40.28%. Presently, SSI between the two most similar physiognomies in 2013 is 48.9% representing a 21.4% increase. SSI value between RF and CP in 2013 was 21.11%, presently, SSI value is 35.1% amounting to a 66.27% increase. Moreover, SSI value in 2013 between RF and TF was 16.54% presently the value is 39.3% representing more than a 100% increase in the SSI value. (Table 4.13)

Table 4.13: Temporal changes in Sorensen's index (%) of similarity of the three Physiognomies of the study area.

Physiognomies	Period	RF	CP	TF
RF	**2013**	-		
	present study	-		
CP	**2013**	21.11	-	
	present study	35.10	-	
TF	**2013**	16.54	40.28	-
	present study	39.3	48.90	-

RF – Regrowth forest

CP – Cocoa plantation

TF – Tree fallow

4.4.2 – **Temporal changes in woody species density**

In 2013, a total of 3347 individuals per hectare were encountered in the study site, presently, the density of woody species in all the th ree physiognomies was 952 individuals per hectare representing a more than a 100% decrease in the density of species in the study area. In the RF in 2013, the density of species per hectare was 1483 presently, the density of individuals in the physiognomies is 484 representing a more than a 100% decrease in the density of species in the physiognomies. Furthermore, in the CP the 2013 density value was 1072 individual per hectare, presently, the value is 292 indicating more than a 100% decrease in the density figure In the TF, the 2013 density of woody species was 792 individuals per hectare, presently, the density value is 176 individuals per hectare accounting for more than 100% decrease in the density of the physiognomy.

Furthermore, in terms of species contribution to densities in each physiognomy, in 2013, dominant species in the RF *Trichilia prieureana* (160 individuals per hectare), *Rothmania longiflora*, *Celti s zenkeri*, *Pterygota macrocapa* (96 species per hectare). Presently, dominant species i n the RF are *Trichilia prieureana*, (92 species per hectare), *Lecaniodiscus cupanioides* , (60 species per hectare) and *Diospyros* Sp (56 species per hectare). Moreover, in the CP two species were dominant which included *Theobroma cacao* (640 species per hectare) which account for about 60% of the total density and *Cola acuminata* (208 species per hectare). Presently, only one species was dominant which is *Theobroma cacao* with 268 species per hectare which account for about 91.80% of the total density of the physiognomy. In the TF in 2013, dominant species in terms of density include *Gliricidia sepium* (296) which account for 37% of the total density in the physiognomy. Presently, In TF, dominant species in terms of density was *Gliricidia sepium* with 164 individuals per hectare which account for 93.20% of the total density. (Table 4.14)

Table 4.14: **Temporal changes in the woody species stnads density (per hectare) in the physiognomies in Ibodi Monkey forest, Ibodi, Osun St ate.**

Physiognomies	Year	Density
RF	2013	1483
	present study	484
CP	2013	1072
	present study	292
TF	2013	792
	present study	176

RF – Regrowtt forest

CP – Cocoa plantation

TF – Tree fallow

4.4.3 – Temporal changes in the basal area

In 2013, the RF had the mean basal area (MBA) (per hectare) of 40.91 $m^2.ha^{-1}$, presently, the value is 17.96 $m^2.ha^{-1}$ amounting to 56.10% decrease in the MBA of species in the physiognomy furthermore, in the CP in 2013, MBA was 21.44 $m^2.ha^{-1}$ presently the MBA is 13.12 $m^2.ha^{-1}$, amounting to 38.81% decrease in the MBA in the physiognomy. Moreover, the MBA in the TF in 2013 was 2.55 $m^2.ha^{-1}$, presently, MBA in the TF is 1.93 $m^2.ha^{-1}$ representing a 24.31% decrease in the MBA value in the TF.

The contribution of each species to the overall MBA over the period of time in each ph ysiognomy showed that in 2013, RF, *Celtis zenkeri* contributed the largest MBA of 10. 08 m^2ha^{-1} (25% of the total), *Chassalia kolly* had the lowest MBA of 0.0066 m^2ha^{-1} while others have intermediate values. Presently, *Pterygota macrocarpa* contributed the largest MBA of 4.95 $m^2.ha^{-1}$ (27.60% of the total), *Carpolobia lutea* had the lowest MBA of 0.00039 $m^2.ha^{-1}$ while other species had intermediate values. Moreover, in the CP in 2013. *Theobroma cacao* contributed the largest MBA of 18.96 $m^2.ha^{-1}$ (88.40% of total), *Citrus sinesis* had the smallest MBA of 0.014 $m^2.ha^{-1}$ while others have intermediate values. Presently, *Theobroma cacao* still remained th e highest contributing species with MBA of 12.43 $m^2.ha^{-1}$ (94.80% of the total), *Voacanga africana* had the smallest MBA of 0.064 $m^2.ha^{-1}$ while other species had intermediate values. Furthermore, in the TF in 2013, *Gliricid ia sepium* contributed the largest MBA of 5.83 $m^2.ha^{-1}$ (92% of the total), *Alchornea cordifolia* had the smallest MBA of 0.000032 $m^2.ha^{-1}$ while others have intermediate values. Presently, *Gliricidia sepium* is still the species with the largest MBA in physiognomies with a value of 1.61 $m^2.ha^{-1}$ in the TF (83.60% of total), *Rauvolfia vomitoria* had the smallest MBA of 0.0046 $m^2.ha^{-1}$ while other species had intermediate values.

Table 4.15: **Temporal change in basal area (per hectare) of woody species in the t hree physiognomies in Ibodi Monkey forest, Ibodi, Osun State.**

Physiognomies	**Year**	**Mean basal area** ($m^2.ha^{-1}$)
RF	2013	40.91
	present study	17.96
CP	2013	21.44
	present study	13.12
TF	2013	2.55
	present study	1.93

RF – Regrowth forest

CP – Cocoa plantation

TF – Tree fallow

Table 4.16: Summary of temporal changes in floristic composition and Structural characteristics of the three physiognomies in Ibodi monkey forest.

S/N	Attributes	year	RF	CP	TF
1	Number of families	2013	35	34	36
		present	43 *	39 *	44*
2	Number of woody species	2013	60	26	41
		present	57 **	40*	50*
3	Number of trees	2013	40	17	30
		present	44*	29*	30*
4	Number of shrub	2013	20	9	18
		present	13**	11*	20*
5	Number of herbs	2013	5	17	15
		present	11*	23*	32*
6	Number of other non woody species	2013	12	11	23
		present	19*	23*	25*
7	Density of woody (ha^{-1})	2013	1483	1072	792
		present	484**	292**	176**
8	Mean Basal area (m^2ha^{-1})	2013	40.91	21.44	6.28
		present	17.96**	13.12**	1.93**
9	Shannon wiener	2013	3.40	2.50	3.24
		present	3.02**	0.39 **	0.29**
10	Species evenness index	2013	0.93	0.80	0.93
		Present	0.85**	0.24**	0.27**
11	Species richness index	2013	15.81	10.82	13.57
		present	8.83**	1.38 **	0.83**

* Symbolizes increase in the numerical value of attributes

** Symbolizes decrease in the numerical value of attributes

RF – Regrowth forest

CP – Cocoa Plantation

TF – Tree fallow

4.5 Carbon stock in the three physiognomies of Ibodi Monkey forest

4.5.1 Soil organic carbon Nitrogen (N), Organic matter (OM) in the three physiognomies of Ibodi Monkey forest

The soil organic carbon (SOC) ranges in the study area from 2.25±0.14% to 3.29±0.43% at 0-15 cm depth, 1.48±0.20% to 2.58±0.54% at 15-30 cm, 0.79±0.046% to 2.02±0.70% at 30-45 cm and 0.68±0.19% to 1.84±0.69% at 45-60 cm depth. (Table 4.17) (Figure 4.4). In the Regrowth forest physiognomy (RF), the highest mean SOC was found at the depth of 0-15 cm (3.29±0.43%) while the least was found at the 45-60 cm depth (1.84±0.69%) the other two depth has intermediate values (Table 4.17). In the Cocoa plantation physiognomy (CP), the highest SOC was found at the depth of 0-15 cm depth (2.38±0.20%), the least value of SOC was found at the 45 -60 cm depth (0.68±0.19%), and 15-30 cm and 30-45 cm depths had intermediate values (Table 4.17). In the Tree fallow physiognomy (TF), the highest mean SOC was found at the depth of 0-15 cm (2.25±0.14%) while the least however in this physiognomy unlike the previous two was found at the 30-45 cm depth (0.80±0.05%) the other two depths had intermediate values (Table 4.17) (figure 4.5).

The Nitrogen content (N) in the study area ranges from 0.21±0.021% to 0.29±0.049% at 0-15 cm depth, 0.13±0.019% to 0.22±0.064% at 15-30 cm, 0.10±0.01% to 0.18±0.081% at 30-45 cm and 0.09±0.0080% to 0.15±0.049% at 45-60 cm depth. (Table 4.17). N content in the RF was highest at 0-15cm (0.29±0.049%), while the least N content was found in the 45-60 cm depth (0.15±0.049), the other the depth has intermediate values. (Table 4.17). In the (CP), the highest N content was found at the depth of 0-15 cm depth (0.26±0.024%), the least value of N content was found at the 45-60 cm depth (0.093±0.021%), and 15-30 cm and 30-45 cm depths had intermediate values (Table 4.17). In the TF, the highest mean N content was found at the depth of 0-15 cm (0.21±0.021%) while the least, however, was in the depth 45-60 cm (0.09±0.008%) the other two depths had intermediate values. (Table 4.17).

The Organic matter (OM) ranges in the study area from 3.88±0.25% to 5.67±0.74% at 0-15 cm depth, 1.78±0.11% to 4.44±0.93% at 15-30 cm, 1.37±0.079% to 3.48±1.20% at 30-45 cm and 1.17±0.32% to 3.16±1.19% at 45-60 cm depth. (Table 4.17) (Figure

4.6). Furthermore, in the (RF), the highest mean Organic matter content (OM) was found at the depth of 0-15 cm (5.67±0.74%) while the least was found at the 45-60 cm depth (3.16±1.19%) the other two depth has intermediate values. (Table 4.17). In the (CP), the highest OM content was found at the depth of 0-15 cm depth (4.11±0.35%), the least value of OM content was found at the 45-60 cm depth (1.17±0.32%), and 15-30 cm and 30-45 cm depths had intermediate values. (Table 4.17). In the TF, the highest mean OM content was found at the depth of 0-15 cm (3.88±0.25%) while the least however was in the depth 45-60 cm (1.38±0.11%) the other two depths had intermediate values. (Table 4.17).

There was a significant difference in the OC%, %OM, %N across RF and TF but no significant difference in CP ($t_3 = 7.848$, $p<0.05$). There was significant difference in the value of OC%, %OM, %N across 0-15, 15-30, 30-45, 45-60 cm in the RF and TF but not with the CP ($t_3 = 3.762$, $p<0.05$)

Table 4.17: **Soil organic carbon, Organic matter and Nitrogen content in all three physiognomies in Ibodi Monkey forest**

DEPT	PHYSIOGNOMIES								
	RF			CP			TF		
	OC%	%N	%OM	OC%	%N	%OM	OC%	%N	%OM
0-15	3.29±0.43	0.29±0.049	5.67±0.74	2.38±0.20	0.26±0.024	4.11±0.35	2.25±0.14	0.21±0.021	3.88±0.25
15-30	2.58±0.54	0.22±0.064	4.44±0.93	1.03±0.060	0.13±0.019	1.78±0.11	1.48±0.20	0.18±0.026	2.55±0.34
30-45	2.02±0.70	0.18±0.081	3.48±1.20	0.89±0.040	0.13±0.012	1.53±0.070	0.80±0.050	0.10±0.010	1.37±0.079
45-60	1.84±0.69	0.15±0.049	3.16±1.19	0.68±0.19	0.093±0.021	1.17±0.32	0.81±0.070	0.09±0.0080	1.38±0.11

RF – Regrowth forest Physiognomy

CP – Cocoa Plantation Physiognomy

TF – Tree fallow Physiognomy

OC – Organic carbon

OM – Organic matter

N – Nitrogen

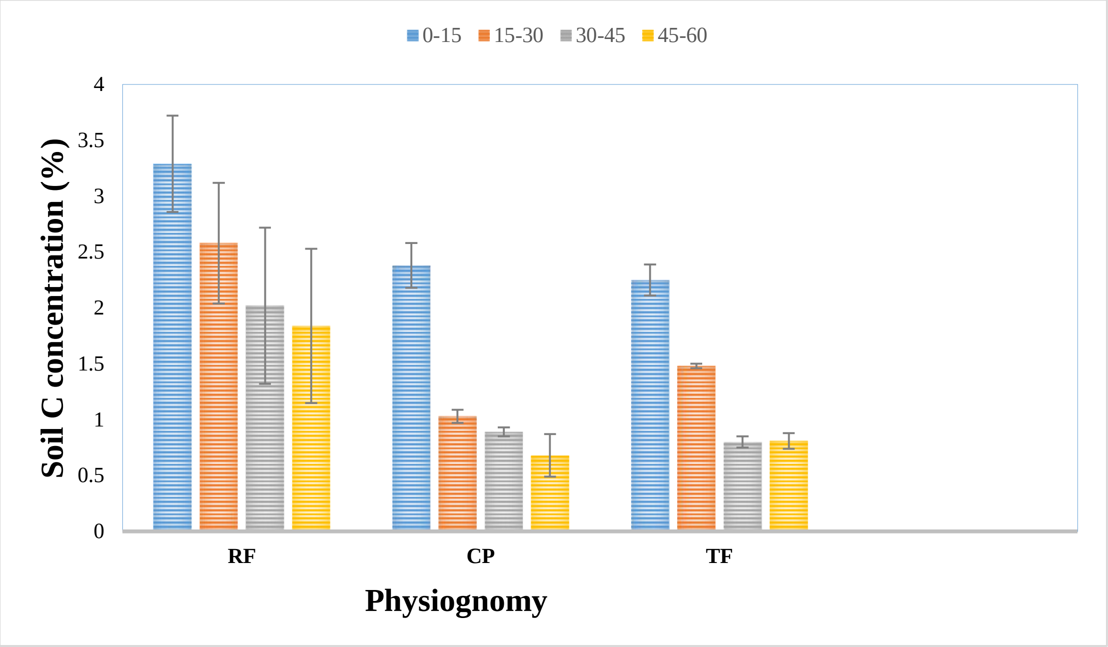

Figure 4.4: Soil organic C concentrations (%) in the different sampled soil depth of the different physiognomies in Ibodi Monkey Forest, Osun state, Nigeria

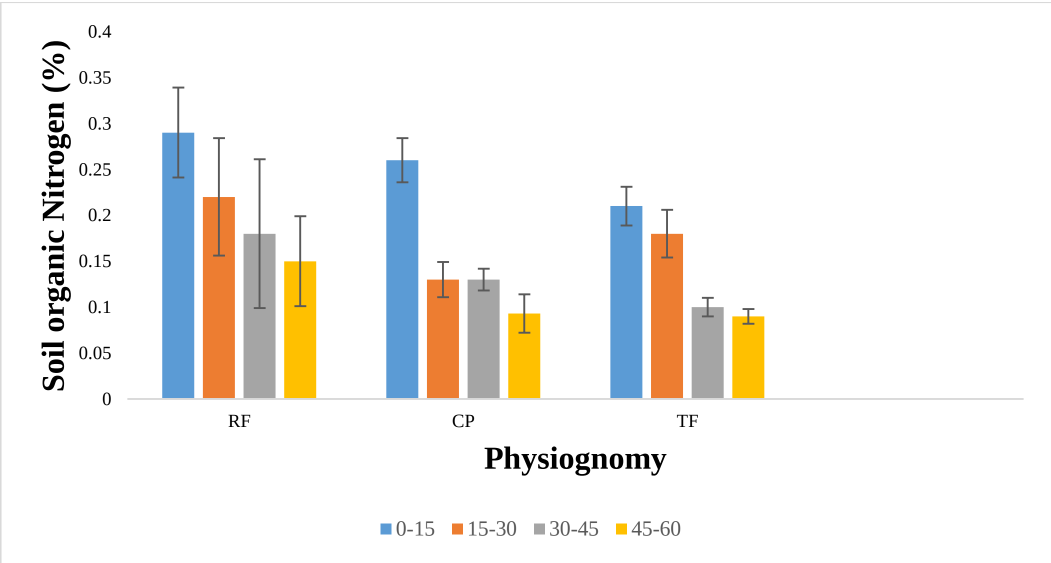

Figure 4.5: Soil organic C concentrations (%) in the different sampled soil depth of the dif ferent physiognomies in Ibodi Monkey Forest, Osun state, Nigeria

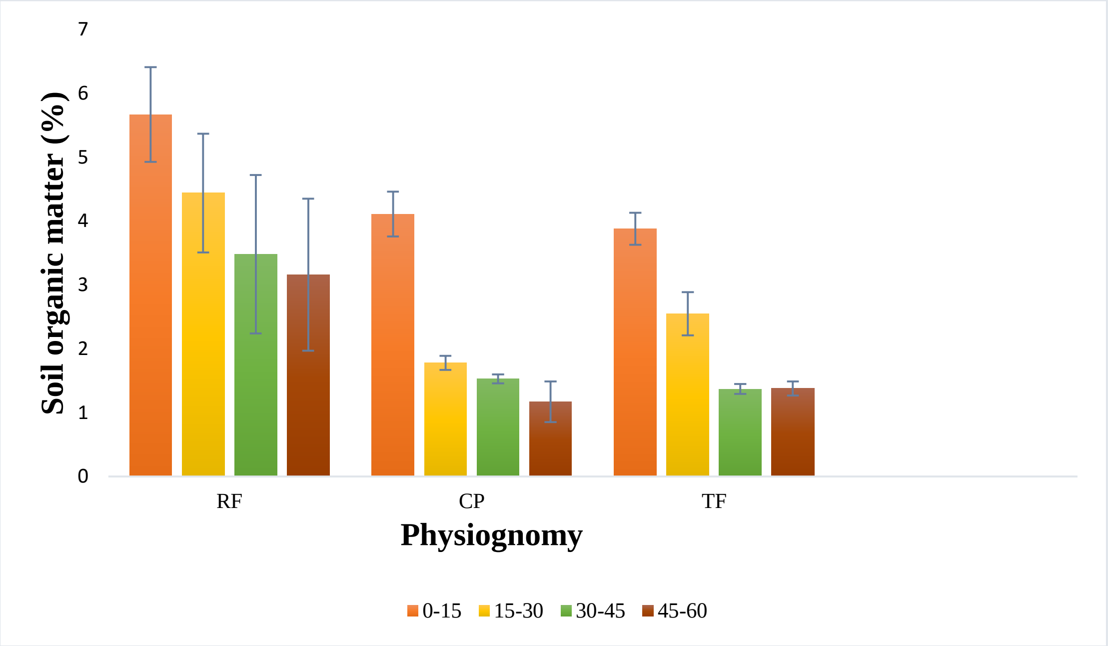

Figure 4.6: Soil organic matter concentrations (%) in the different sampled soil depth of the different physiognomies in Ibodi Monkey Forest, Osun state, Nigeria

4.5.2 Soil Carbon Stocks in three physiognomies in Ibodi Monkey forest

The total soil C Stocks in three physiognomies in Ibodi Monkey forest pools are summed u p in Table 4.18 with a total value of 333.11 $t.h^{-1}$.

The RF had the highest carbon stock value of 144.34 $t.h^{-1}$. Furthermore, 45-60 cm depth had the highest carbon stock value of 48.58 $t.h^{-1}$ while 0-15 cm had the least value of 21.71 $t.ha^{-1}$. CP had the least carbon stock value among the three physiognomy (94.37 $t.ha^{-1}$). Moreover, 45-60 cm had the highest carbon stock value of 26.11 $t.ha^{-1}$ with 15-30 cm depth have the least value of 19.78 $t.ha^{-1}$.

Carbon stock value of 94.40 $t.ha^{-1}$ was obtained for the TF with the soil depth of 45-60 cm having the highest value of 28.12 $t.ha^{-1}$ while the least stock was in the soil depth 0-15 cm (19.58 $t.ha^{-1}$).

There was significant difference in the carbon stock value among the three physiogno mies ($f_{(3, 1)}$ = .0021, $p<.05$ p= .000). Furthermore, there was no significant difference with depth across the three physiognomies; RF, CP, TF ($f_{(3, 1)}$ = 2.45, $p>.05$ p =.07). Th ere was significant difference across different depth examined up to 60 cm ($f_{(3, 1)}$ =.040, $p<.05$) p=0.02

Table 4.18: Soil carbon stock ($t.ha^{-1}$) in the three physiognomies in Ibodi monkey forest

Soil Depth range	% carbon	Soil depth	Bulk density ($g.cm^{-3}$)	Carbon ($t.ha^{-1}$)
Regrowth forest Physiognomy (RF)				
0-15	3.29	15	0.44	**21.71**
15-30	2.58	30	0.44	**34.10**
30-45	2.02	45	0.44	**40.00**
45-60	1.84	60	0.44	**48.58**
		Total		**144.34**
Cocoa plantation physiognomy (CP)				
0-15	2.38	15	0.64	**22.85**
15-30	1.03	30	0.64	**19.78**
30-45	0.89	45	0.64	**25.63**
45-60	0.68	60	0.64	**26.11**
		Total		**94.37**
Tree fallow physiognomy (TF)				
0-15	2.25	15	0.58	**19.58**
15-30	1.48	30	0.58	**25.75**
30-45	0.8	45	0.58	**20.88**
45-60	0.81	60	0.58	**28.12**
		Total		**94.40**

4.5.3 Aboveground biomass and carbon stock in Ibodi Monkey forest

4.5.3.1 The Selection of Allometric Equation

Assessment of the allometric equations was done using each of the equations to generate aboveground biomass estimates for woody species (with DBH ≥ 10 cm) in the three physiognomies.

The reliability of the different equations was based on the value of F value, R^2 and adjusted R^2 . The first allometric equation (Chave *et al*., 2005) gave the best prediction based on the criteria stated above in the regrowth forest physiognomy (RF) and Cocoa plantation physiognomy (CP), while Feldpausch *et al*., 2012 was suitable for Tree fallow physiognomy. (Table 4.19)

In (RF), the decreasing trend of the 5 allometric in estimating the aboveground biomass suitability is $0.0509 \times (\rho) \times ((DBH)^2) \times H > 0.0673 \times ((\rho \times (DBH)^2 \times H))^{0.976} > 0.0347 \times (\rho)^2 \times (DBH)^2 \times H > \exp(-2.9205) + (0.9894 \times \ln((DBH^2)) \times \rho \times H) > \exp(-2.436) + (0.1399 \times \ln(DBH)^2) + (0.7373 \times (\ln(DBH)^2) x H) + (0.279 \times \ln(\rho)$

In (CP), the decreasing trend of the 5 allometric in estimating the aboveground biomass suitability is $0.0509 \times (\rho) \times ((DBH)^2) \times H > 0.0347 \times (\rho)^2 \times (DBH)^2 \times H > 0.0673 \times ((\rho \times (DBH)^2 \times H))^{0.976} > \exp(-2.9205) + (0.9894 \times \ln((DBH^2)) \times \rho \times H) > \exp(-2.436) + (0.1399 \times \ln(DBH)^2) + (0.7373 \times (\ln(DBH)^2) x H)$

$+ (0.279 \times \ln(\rho)$

In (CP), the decreasing trend of the 5 allometric in estimating the aboveground biomass suitability is $\exp(-2.9205) + (0.9894 \times \ln((DBH^2)) \times \rho \times H) > \exp(-2.436) + (0.1399 \times \ln(DBH)^2) + (0.7373 \times (\ln(DBH)^2) x H) + (0.279 \times \ln(\rho)$ > Henry *et al*, 2010 > $0.0509 \times (\rho) \times ((DBH)^2) \times H > 0.0673 \times ((\rho \times (DBH)^2 \times H))^{0.976}$.

Table 4.19: Multiple regression analysis of different allometric equations in estimating the aboveground biomass (AGB) in the three physiognomies in Ibodi monkey forest

Physiognomies	Variable	R	R Square	Adjusted R Square	df	F	Sig.
RF	1	1.000[a]	1.000	1.000	35	864790.81	.000[b]
	2	.995[a]	.990	.989	35	1066.61	.000[b]
	3	.981[a]	.963	.959	35	274.10	.000[b]
	4	.992[a]	.985	.983	35	690.91	.000[b]
	5	1.000[a]	1.000	1.000	35	877358.83	.000[b]
CP	1	1.000[a]	1.000	1.000	38	738957171.39	.000[b]
	2	1.000[a]	1.000	1.000	38	765424062.40	.000[b]
	3	.996[a]	.991	.991	38	2073.86	.000[b]
	4	.998[a]	.995	.995	38	3774.10	.000[b]
	5	1.000[a]	1.000	1.000	38	346525967.76	.000[b]
TF	1	1.000[a]	1.000	1.000	48	-	-
	2	1.000[a]	1.000	1.000	48	-	-
	3	.999[a]	.999	.999	48	22455.95	.000[b]
	4	.999[a]	.999	.999	48	18963.68	.000[b]
	5	1.000[a]	1.000	1.000	48	-	-

1: Chave *et al*., 2005 **2:** Henry *et al*, 2010 **3:** Djomo *et al*., 2010 **4:** Feldpausch *et al*., 2012 **5:** Chave *et al*., 2014

RF – Regrowth forest Physiognomy

CP – Cocoa Plantation Physiognomy

TF – Tree fallow Physiognomy

4.5.3.2 Aboveground biomass of woody species in the three physiognomies

The total Aboveground Biomass (AGB) (kg.ha^{1}) in all the three physiognomies was 6866 15.85 kg.ha^{-1}. The AGB in the three physiognomies ranges from 60815.01 kg.ha^{-1} in the Tree Fallow Physiognomy to 441160.98 kg.ha^{-1} in the Regrowth forest physiognomy (RF) with the cocoa plantation physiognomy have intermediate value. The study site biomass found in RF was 64.25%, 26.89% and 8.86% in CP and TF respectively. (Table 4.21-4.22)

In the RF, *Trichilia prieuriana* (111618.94 Kg.ha^{-1}) and *Pterygota macrocarpa* (111420.47 Kg.ha^{-1}) contributed the highest AGB in the physiognomy, contributing 25.30% and 25.26% respectively of the AGB value. *Carpolobia lutea* (0.85 kgha^{-1}) had the least AGB (0.00019%) (Table 4.20).

In the CP, *Theobroma cacao* (174042.21 Kg.ha^{-1}) contributed the highest AGB in the physiognomy (94.26%). *Voacanga africana* (391.68 Kg.ha^{-1}) had the least AGB (0.21%) (Table 4.21).

In TF and RF physiognomies *Gliricidia sepium* (55071.68 Kg.ha^{-1}) contributed the highest AGB (90.56%). *Rauvolfia vomitoria* (28.04 Kg.ha^{-1}) had the least AGB (0.046%) (Table 4.22).

Table 4.20: Aboveground biomass of woody species in the Regrowth Forest (RF) physiognomy

S/No	Name	Family	DBH (cm)	Height (cm)	Specific wood gravity (g.cm^{-3})	Aboveground Biomass (AGB) (Kg.ha^{-1})
1	*Albizia zygia*	Mimosaceae	10.18	303.00	0.55	882.90
2	*Alchornea cordifolia*	Euphorbiaceae	4.22	150.00	0.54	73.05
3	*Alstonia boonei*	Apocynaceae	3.34	103.00	0.39	22.68
4	*Baphia nitida*	Papilionaceae	29.92	980.00	0.57	25351.59
5	*Canthium sp*	Rubiaceae	1.67	230.00	0.72	23.36
6	*Carpolobia lutea*	Polygalaceae	0.56	120.00	0.45	0.85
7	*Ceiba pentandra*	Bombacaceae	1.91	150.00	0.35	9.86
8	*Celtis sp*	Ulmaceae	3.26	175.00	0.63	59.72
9	*Chrysophyllum albidium*	Sapotaceae	19.33	960.00	0.59	10733.80
10	*Cola millenii*	Sterculiaceae	4.93	250.00	0.52	161.99
11	*Cordia sp*	Boraginaceae	24.67	1025.00	0.42	13191.96
12	*Deinbollia pinnata*	Sapindaceae	8.36	220.00	0.52	408.86
13	*Diospyros sp*	Ebenaceae	36.12	1052.00	0.80	55898.85
14	*Diospyros barteri*	Ebenaceae	3.341	110.00	0.70	43.58
15	*Dracaenea manii*	Dracaenaceae	13.45	520.00	0.37	1775.56

16	*Elaeis guineensis*	Arecaceae	18.06	1020.00	0.47	7960.41
17	*Khaya grandifoliola*	Meliaceae	5.17	230.00	0.66	207.60
18	*Lecaniodiscus cupanioides*	Sapindaceae	39.15	960.00	0.77	57660.39
19	*Monodora myristica*	Annonaceae	6.60	162.00	0.49	176.22
20	*Morinda lucida*	Rubiaceae	5.49	288.00	0.51	224.90
21	*Myrianthus arboreus*	Moraceae	7.72	302.10	0.69	633.85
22	*Napoleonaea vogelii*	Lecythidiaceae	1.27	106.00	0.35	3.01
23	*Newbouldia laevis*	Bignoniaceae	16.63	899.00	0.21	2594.13
24	*Pentaclethra macrophylla*	Mimosaceae	1.91	101.00	0.82	15.38
25	*Pterygota macrocarpa*	Sterculiaceae	62.79	1136.00	0.49	111420.47
26	*Pterygota sp*	Sterculiaceae	11.70	1003.00	0.57	3974.33
27	*Sterculia rhinopetala*	Sterculiaceae	0.80	109.00	0.67	2.36
28	*Sterculia tragacantha*	Sterculiaceae	5.81	198.00	0.57	193.81
29	*Strombosia pustulata*	Olacaceae	4.69	206.00	0.83	191.79
30	*Tabernaemontana pachysiphon*	Apocynaceae	12.73	890.00	0.51	3759.11
31	*Trichilia monedelpha*	Meliaceae	4.217	206.00	0.46	85.78
32	*Trichilia prieuriana*	Meliaceae	52.59	1196.00	0.66	111618.94
33	*Trilepisium madagascariensis*	Moraceae	20.53	952.00	0.50	10197.48

34	*Triplochiton scleroxylon*	Sterculiaceae	27.85	1190.00	0.44	20434.20
35	*Voacanga africana*	Apocynaceae	4.85	290.00	0.49	171.08
36	*Zanthoxyllum sp*	Rutaceae	8.28	523.00	0.55	997.11
					TOTAL	**441160.98**

Table 4.21: Aboveground biomass of woody species in the Cocoa Plantation (CP) physiognomy

S/No	Name	Family	DBH (cm)	Height (cm)	Specific wood gravity (g.cm^{-3})	Aboveground Biomass (AGB) (Kg.ha^{-1})
1	*Albizia ferruginea*	Mimosaceae	8.91	502.00	0.49	1002.43
2	*Elaeis guineensis*	Arecaceae	18.70	1023.00	0.47	8556.47
3	*Theobroma cacao*	Sterculiaceae	99.46	823.00	0.42	174042.21
4	*Vitex doniana*	Verbenaceae	7.96	502.00	0.40	647.07
5	*Voacanga africana*	Apocynaceae	7.16	305.00	0.49	391.68
					TOTAL	**184639.86**

Table 4.22: Aboveground biomass of woody species in the Tree Fallow (TF) physiognomy

S/No	Name	Family	DBH (cm)	Height (cm)	Specific wood gravity ($g.cm^{-3}$)	Aboveground Biomass (AGB) ($Kg.ha^{-1}$)
1	*Citrus sinensis*	Rutaceae	15.75	580.00	0.78	5715.29
2	*Gliricidia sepium*	Papilionaceae	35.81	1508.00	0.56	55071.68
3	*Rauvolfia vomitoria*	Apocynaceae	1.91	320.00	0.47	28.04
					TOTAL:	**60815.01**

4.5.3.3 Carbon stock estimate in aboveground pool in Ibodi monkey forest

Carbon fraction of 0.5 t C t^{-1} was used to estimate the carbon stock in the aboveground pool of the three physiognomies in Ibodi monkey forest from the aboveground biomass (AGB).

The total estimated carbon stock in the aboveground pool in all the three physiognomies was 5492.93 t C ha^{-1}. The aboveground carbon stock pool in the three physiognomies ranges from 486.52 t C ha^{-1} in the tree fallow physiognomy (TF) (8.86%) to 3529.29 t C ha^{-1} in the Regrowth forest physiognomy (RF) (64.25%) with the cocoa plantation physiognomy (CP) (26.89%) having the intermediate value (1477.12 t C ha^{-1}). (Table 4.23-4.25)

In the RF *Trichilia prieuriana* (892.95 t C ha^{-1}) and *Pterygota macrocarpa* (891.36 t C ha^{-1}) contributed the highest carbon stock in the physiognomy, contributing 25.30% and 25.26 %, respectively of the carbon stock value. *Carpolobia lutea* (0.0068 t C ha^{-1}) had the least carbon stock (0.00019%). (Table 4.23)

In the CP, *Theobroma cacao* (1392.34 t C ha^{-1}) contributed the highest carbon stock in the physiognomy (94.26%). *Voacanga africana* (3.13 t C ha^{-1}) had the least carbon stock (0.21%). (Table 4.24)

In the TF, *Gliricidia sepium* (440.57 t C ha^{-1}) contributed the highest carbon stock in the physiognomy (90.56%). *Rauvolfia vomitoria* (0.22 t C ha^{-1}) had the least carbon stock contributing 0.046% to the total carbon stock. (Table 4.25)

Table 4.23: Carbon stock estimate in aboveground pool in Regrowth forest physiognomy in Ibodi monkey forest

S/No	Names	families	AGB(kgha-1)	ABG (t)	Scaling factor	carbon fraction CF (t C t^{-1})	Carbon Stock t C ha^{-1}
1	*Albizia zygia*	Mimosaceae	882.90	0.88	16.00	0.50	7.06
2	*Alchornea cordifolia*	Euphorbiaceae	73.05	0.073	16.00	0.50	0.58
3	*Alstonia boonei*	Apocynaceae	22.68	0.023	16.00	0.50	0.18
4	*Baphia nitida*	Papilionaceae	25351.59	25.35	16.00	0.50	202.81
5	*Canthium sp*	Rubiaceae	23.36	0.023	16.00	0.50	0.19
6	*Carpolobia lutea*	Polygalaceae	0.85	0.0010	16.00	0.50	0.0068
7	*Ceiba pentandra*	Baombacaceae	9.86	0.010	16.00	0.50	0.079
8	*Celtis sp*	Ulmaceae	59.72	0.060	16.00	0.50	0.48
9	*Chrysophyllum albidium*	Sapotaceae	10733.80	10.73	16.00	0.50	85.87
10	*Cola millenii*	Sterculiaceae	161.99	0.16	16.00	0.50	1.30
11	*Cordia sp*	Boraginaceae	13191.96	13.19	16.00	0.50	105.54
12	*Deinbollia pinnata*	Sapindaceae	408.86	0.41	16.00	0.50	3.27
13	*Diospyros sp*	Ebenaceae	55898.85	55.90	16.00	0.50	447.19
14	*Diospyros barteri*	Ebenaceae	43.58	0.044	16.00	0.50	0.35
15	*Dracaenea manii*	Dracaenaceae	1775.56	1.78	16.00	0.50	14.20
16	*Elaeis guineensis*	Arecaceae	7960.41	7.96	16.00	0.50	63.68
17	*Khaya grandifoliola*	Meliaceae	207.60	0.21	16.00	0.50	1.66
18	*Lecaniodiscus cupanioides*	Sapindaceae	57660.39	57.66	16.00	0.50	461.28
19	*Monodora myristica*	Annonaceae	176.22	0.18	16.00	0.50	1.41
20	*Morinda lucida*	Rubiaceae	224.90	0.22	16.00	0.50	1.80
21	*Myrianthus arboreus*	Moraceae	633.85	0.63	16.00	0.50	5.07
22	*Napoleonaea vogelii*	Lecythidiaceae	3.01	0.0030	16.00	0.50	0.024
23	*Newbouldia laevis*	Bignoniaceae	2594.13	2.59	16.00	0.50	20.75

24	*Pentaclethra macrophylla*	Mimosaceae	15.38	0.015	16.00	0.50	0.12
25	*Pterygota macrocarpa*	Sterculiaceae	111420.47	111.42	16.00	0.50	891.36
26	*Pterygota sp*	Sterculiaceae	3974.33	3.97	16.00	0.50	31.79
27	*Sterculia rhinopetala*	Sterculiaceae	2.36	0.0024	16.00	0.50	0.019
28	*Sterculia tragacantha*	Sterculiaceae	193.81	0.19	16.00	0.50	1.55
29	*Strombosia pustulata*	Olacaceae	191.79	0.19	16.00	0.50	1.53
30	*Tabernaemontana pachysiphon*	Apocynaceae	3759.11	3.76	16.00	0.50	30.07
31	*Trichilia monedelpha*	Meliaceae	85.78	0.086	16.00	0.50	0.69
32	*Trichilia prieuriana*	Meliaceae	111618.94	111.62	16.00	0.50	892.95
33	*Trilepisium madagascariensis*	Moraceae	10197.48	10.20	16.00	0.50	81.58
34	*Triplochiton scleroxylon*	Sterculiaceae	20434.20	20.43	16.00	0.50	163.47
35	*Voacanga africana*	Apocynaceae	171.08	0.17	16.00	0.50	1.37
36	*Zanthoxyllum sp*	Rutaceae	997.11	0.10	16.00	0.50	7.98
				TOTAL:			**3529.29**

Table 4.24: Carbon stock estimate in aboveground pool in Cocoa plantation physiognomy in Ibodi monkey forest

S/No	Species	Family	Aboveground Biomass AGB (kgha-1)	Aboveground Biomass ABG (t)	Scaling factor	Carbon Fraction CF (t C t^{-1})	Carbon Stock t C ha^{-1}
1	*Albizia ferruginea*	Mimosaceae	1002.43	1.00	16.00	0.50	8.02
2	*Elaeis guineensis*	Arecaceae	8556.47	8.56	16.00	0.50	68.45
3	*Theobroma cacao*	Sterculiaceae	174042.21	174.04	16.00	0.50	1392.34
4	*Vitex doniana*	Verbenaceae	647.07	0.65	16.00	0.50	5.18
5	*Voacanga africana*	Apocynaceae	391.68	0.39	16.00	0.50	3.13
					TOTAL:		**1477.12**

Table 4.25: Carbon stock estimate in aboveground pool Tree fallow physiognomy in Ibodi monkey forest

S/No.	Species Name	family	AGB (kgha-1)	ABG (t)	Scaling factor	carbon fraction CF (t C t^{-1})	Carbon Stock t C ha^{-1}
1	*Citrus sinensis*	Rutaceae	5715.29	5.72	16.00	0.50	45.72
2	*Gliricidia sepium*	Papilionaceae	55071.68	55.07	16.00	0.50	440.57
3	*Rauvolfia vomitoria*	Apocynaceae	28.04	0.028	16.00	0.50	0.22
			TOTAL:				486.52

4.5.4 Belowground biomass and carbon stock

The Belowground biomass and carbon stock were estimated from the aboveground biomass (AGB). The total belowground biomass (BGB) and belowground carbon stock in all the three physiognomies were 102990 kgha^{-1} and 823.94 t C ha^{-1}. The BGB in the three physiognomies ranges from 912 kgha-1 in the tree fallow physiognomy to 66170 kgha-1 in the Regrowth forest physiognomy (RF) with the cocoa plantation physiognomy having an intermediate value. Below ground carbon stock ranges from 72.98 t C ha^{-1} in the TF to 529.39 t C ha^{-1} in the RF. In the study site, RF contributed 64.25% of the biomass, CP yielded 26.89% and TF produced 8.86% of the biomass. (Table 4.26-4.28)

In the RF *Trichilia prieuriana* with biomas of 16742.84 kgha^{-1}, carbon stock value of 133.94 t C ha^{-1} and *Pterygota macrocarpa* with biomass 16713.07kgha^{-1}, carbon stock value of 133.70 t C ha^{-1} contributed the highest BGB and carbon stock in the physiognomy contributing 25.30% and 25.26% respectively of the BGB and carbon stock value. *Carpolobia lutea* (0.13 kgha-1) had the least BGB contributing 0.00019% of the AGB value (Table 4.26).

In the CP, *Theobroma cacao* with biomass 26106.33 kgha^{-1}, carbon stock value of 208.85 t C ha^{-1} contributed the highest BGB (94.62%) and carbon stock in the CP. Physiognomy. *Voacanga africana* with biomass 58.75 kgha^{-1}, with a carbon stock value of 0.47 t C ha^{-1} had the least BGB and carbon stock contributing 0.21% of the BGB and carbon stock value (Table 4.27).

In the TF, In the RF *Gliricidia sepium* with biomass 8260.75 kgha^{-1} with a carbon stock value of 66.09 t C ha^{-1} contributed the highest BGB and carbon stock in the physiognomy contributing 90.56%. *Rauvolfia vomitoria* with biomass 4.21 kgha^{-1}, carbon stock value of 0.03 t C ha^{-1} had the least BGB contributing 0.046% of the BGB and carbon stock value (Table 4.28).

Table 4.26: Belowground biomass and carbon stock in the Regrowth Forest physiognomy

S/No	Names	families	ABG (t)	BGB (t)	Scaling factor	Carbon Fraction (CF) (t C t^{-1})	Carbon stock t C ha^{-1}
1	*Albizia zygia*	Mimosaceae	0.88	0.13	16.00	0.50	1.06
2	*Alchornea cordifolia*	Euphorbiaceae	0.073	0.011	16.00	0.50	0.088
3	*Alstonia boonei*	Apocynaceae	0.023	0.0034	16.00	0.50	0.027
4	*Baphia nitida*	Papilionaceae	25.35	3.80	16.00	0.50	30.42
5	*Canthium sp*	Rubiaceae	0.023	0.0035	16.00	0.50	0.028
6	*Carpolobia lutea*	Polygalaceae	0.00085	0.00013	16.00	0.50	0.0010
7	*Ceiba pentandra*	Baombacaceae	0.0099	0.0015	16.00	0.50	0.012
8	*Celtis sp*	Ulmaceae	0.060	0.0090	16.00	0.50	0.071
9	*Chrysophyllum albidium*	Sapotaceae	10.73	1.61	16.00	0.50	12.88
10	*Cola millenii*	Sterculiaceae	0.16	0.024	16.00	0.50	0.19
11	*Cordia sp*	Boraginaceae	13.19	1.98	16.00	0.50	15.83
12	*Deinbollia pinnata*	Sapindaceae	0.41	0.061	16.00	0.50	0.49
13	*Diospyros Sp*	Ebenaceae	55.90	8.38	16.00	0.50	67.08
14	*Diospyros barteri*	Ebenaceae	0.044	0.0065	16.00	0.50	0.05
15	*Dracaenea manii*	Dracaenaceae	1.78	0.27	16.00	0.50	2.13
16	*Elaeis guineensis*	Arecaceae	7.96	1.19	16.00	0.50	9.55
17	*Khaya grandifoliola*	Meliaceae	0.21	0.031	16.00	0.50	0.25
18	*Lecaniodiscus cupanioides*	Sapindaceae	57.66	8.65	16.00	0.50	69.19
19	*Monodora myristica*	Annonaceae	0.18	0.026	16.00	0.50	0.21
20	*Morinda lucida*	Rubiaceae	0.22	0.034	16.00	0.50	0.27
21	*Myrianthus arboreus*	Moraceae	0.63	0.095	16.00	0.50	0.76
22	*Napoleonaea vogelii*	Lecythidiaceae	0.0030	0.00045	16.00	0.50	0.0036
23	*Newbouldia laevis*	Bignoniaceae	2.59	0.39	16.00	0.50	3.11

24	*Pentaclethra macrophylla*	Mimosaceae	0.015	0.0023	16.00	0.50	0.019
25	*Pterygota macrocarpa*	Sterculiaceae	111.42	16.71	16.00	0.50	133.70
26	*Pterygota sp*	Sterculiaceae	3.97	0.60	16.00	0.50	4.77
27	*Sterculia rhinopetala*	Sterculiaceae	0.0024	0.00035	16.00	0.50	0.0028
28	*Sterculia tragacantha*	Sterculiaceae	0.19	0.029	16.00	0.50	0.23
29	*Strombosia pustulata*	Olacaceae	0.19	0.029	16.00	0.50	0.23
30	*Tabernaemontana pachysiphon*	Apocynaceae	3.76	0.56	16.00	0.50	4.51
31	*Trichilia monedelpha*	Meliaceae	0.086	0.013	16.00	0.50	0.10
32	*Trichilia prieuriana*	Meliaceae	111.62	16.74	16.00	0.50	133.94
33	*Trilepisium madagascariensis*	Moraceae	10.20	1.53	16.00	0.50	12.24
34	*Triplochiton scleroxylon*	Sterculiaceae	20.43	3.07	16.00	0.50	24.52
35	*Voacanga africana*	Apocynaceae	0.17	0.026	16.00	0.50	0.21
36	*Zanthoxyllum sp*	Rutaceae	0.10	0.15	16.00	0.50	1.20
						TOTAL	**66170**

Table 4.27: Belowground biomass and carbon stock in the Cocoa Plantation physiognomy

S/No	Species	Family	ABG (t ha^{-1})	BGB (t ha^{-1})	Scaling Factor	Carbon Fraction (CF) (t C t^{-1})	Carbon stock t C ha^{-1}
1	*Albizia ferruginea*	Mimosaceae	1.00	0.15	16.00	0.50	1.20
2	*Elaeis guineensis*	Arecaceae	8.56	1.28	16.00	0.50	10.27
3	*Theobroma cacao*	Sterculiaceae	174.04	26.11	16.00	0.50	208.85
4	*Vitex doniana*	Verbenaceae	0.65	0.097	16.00	0.50	0.78
5	*Voacanga africana*	Apocynaceae	0.39	0.059	16.00	0.50	0.47
	TOTAL			**27.6960**			**221.57**

Table 4.28: Belowground biomass and carbon stock in the Cocoa plantation physiognomy

S/No.	Species Name	Family	ABG (t ha^{-1})	BGB (t ha^{-1})	Scaling Factor	Carbon Fraction (CF) (t C t^{-1})	Carbon stock t C ha^{-1}
1	Citrus sinensis	Rutaceae	5.72	0.86	16.00	0.50	6.86
2	Gliricidia sepium	Papilionaceae	55.07	8.26	16.00	0.50	66.09
3	Rauvolfia vomitoria	Apocynaceae	0.028	0.0042	16.00	0.50	0.033
	TOTAL			**9.122252**			**72.98**

4.5.5 Litter, saplings and herbaceous species Organic carbon (OC), Nitrogen (N), Organic Matter (OM) in the three physiognomies of Ibodi Monkey forest

The organic carbon content (OC) (%), Total Nitrogen, (N) (%) and organic matter (OM) (%) in the litter, saplings and herbaceous species varied in the three physiognomies of study.

For litter, The OC ranges from 50.496±1.85% in the Cocoa Plantation physiognomy (CP) to 53.964±3.65% in the Tree Fallow (TF) with the Regrowth Forest physiognomy (RF) having the intermidiate value (52.96±1.73%). Organic Matter ranges from 87.64±2.83% in the CP to 92.82±6.50% in the TF. Regrowth Forest physiognomy had 91.30±3.00%. Moreover, N ranges from 2.67±0.33% in the CP to 2.82±0.35% in the TF. Regrowth Forest physiognomy had 2.67±0.33% of N concentration (Table 4.29). Organic Carbon, OM and N were not significantly different throughout the three physiognomies studies.

Furthermore, for herbs and saplings in the study area, Organic Carbon ranges from 56.46±4.47% in the TF, to 56.90±1.08% in the CP with the Regrowth forest physiognomy (RF) having the intermidiate value (56.86±1.02). Organic Matter ranges from 97.34±7.71% in the TF to 98.07±1.85% in the CP. RF had 97.85±1.60% Organic Matter. Moreover, N ranges from 2.84±0.35% in the TF to 3.96±0.98% in the CP. RF had 2.98±0.74% (Table 4.29). Organic Carbon, OM and N were not significantly different throughout the three physiognomies studies.

Table 4.29: **Litter, saplings and herbaceous species organic carbon, Organic matter and Nitrogen content in all three physiognomies in Ibodi Monkey forest**

	LITTER			HERBS AND SAPPLINGS		
	OC%	**OM%**	**N%**	**OC%**	**OM%**	**N%**
RF	52.96±1.73	91.30±3.00	2.73±0.51	56.86±1.02	97.85±1.60	2.98±0.74
CP	50.50±1.85	87.64±2.83	2.67±0.33	56.90±1.08	98.07±1.85	3.96±0.98
TF	53.96±3.65	92.82±6.50	2.82±0.35	56.46±4.47	97.34±7.71	2.84±0.35

OC= Organic Carbon**, OM=** Organic Matter, **N=** Nitrogen

Total Carbon stock in the study area for litter was 0.13 $t.ha^{-1}$ (Table 4.30). The RF had the highest carbon stock value (0.083 $t.ha^{-1}$) with CP and TFF having 0.035 $t.ha^{-1}$ and 0.010 $t.ha^{-1}$ respectively.The biomass in the standing litter ranged from 0.025 $t.ha^{-1}$ in the TF, 0.18 $t.ha^{-1}$ in the RF while CP had 0.075 $t.ha^{-1}$. Moreover, Total Carbon stock in the study area for herbs and sapplings was 0.018 $t. ha^{-1}$.

Futhermore, the TF had the highest carbon stock value (0.0074 $t.ha^{-1}$) with RF and CP having 0.0039 $t.ha^{-1}$ and 0.0068 $t.ha^{-1}$, respectively. The biomass of herbs and saplings ranged from 0.0083 $t.ha^{-1}$ in the RF, 0.016 $t.ha^{-1}$ in the TF while CP had 0.015 $t.ha^{-1}$ (Table 4.30).

Table 4.30: Litter, saplings and herbaceous species biomass and carbon stock in all three physiognomies in Ibodi Monkey forest

	OC%	Dry weight (t)	scaling factor	Biomass ($t.ha^{-1}$)	Carbon stock $t.ha^{-1}$	OC%	Dry weight (t)	scaling factor	Biomass ($t.ha^{-1}$)	Carbon stock $t.ha^{-1}$
	Litter					Herbs and saplings				
RF	52.96	0.00021	16.00	0.18	0.083	56.86	0.000009	16.00	0.0083	0.0039
CP	50.50	0.000093	16.00	0.075	0.035	56.90	0.000016	16.00	0.015	0.0068
TF	53.96	0.000029	16.00	0.025	0.012	56.46	0.000018	16.00	0.016	0.0075
		TOTAL			**0.13**					**0.018**

4.6 Summary of all carbon stock in aboveground, below ground, soil, litter, herbs, sapling and sequestration potential of Ibodi Monkey forest

The total carbon sequestration potential in Ibodi monkey forest was 24386.02 t.CO_2e.ha^{-1} with the aboveground pool and below ground pool having the highest sequestration potential in the study with the value of 20142.57 t.CO_2e.ha^{-1} (82.60%) and 3021.39 t.CO_2e.ha^{-1} (12.35%), respectively. Soil organic carbon pool had a sequestration potential of 1221.51 (5.00%) t.CO_2e.ha^{-1} herbs and sapling pool had the least sequestration potential of 0.55 t.CO_2e.ha^{-1} (0.0023%) (Table 4.31) (Figure 4.7)

Table 4.31: A table showing Sequestration potential of Ibodi Monkey forest

Carbon pool	Carbon stock (t.C.ha^{-1})	Sequestration potential (t.CO_2e.ha^{-1})
Aboveground	5492.93	20142.57
Below ground	823.94	3021.39
Soil	333.11	1221.51
Herbs, Samplings and Litter	0.15	0.55
TOTAL	**6650.13**	**24386.02**

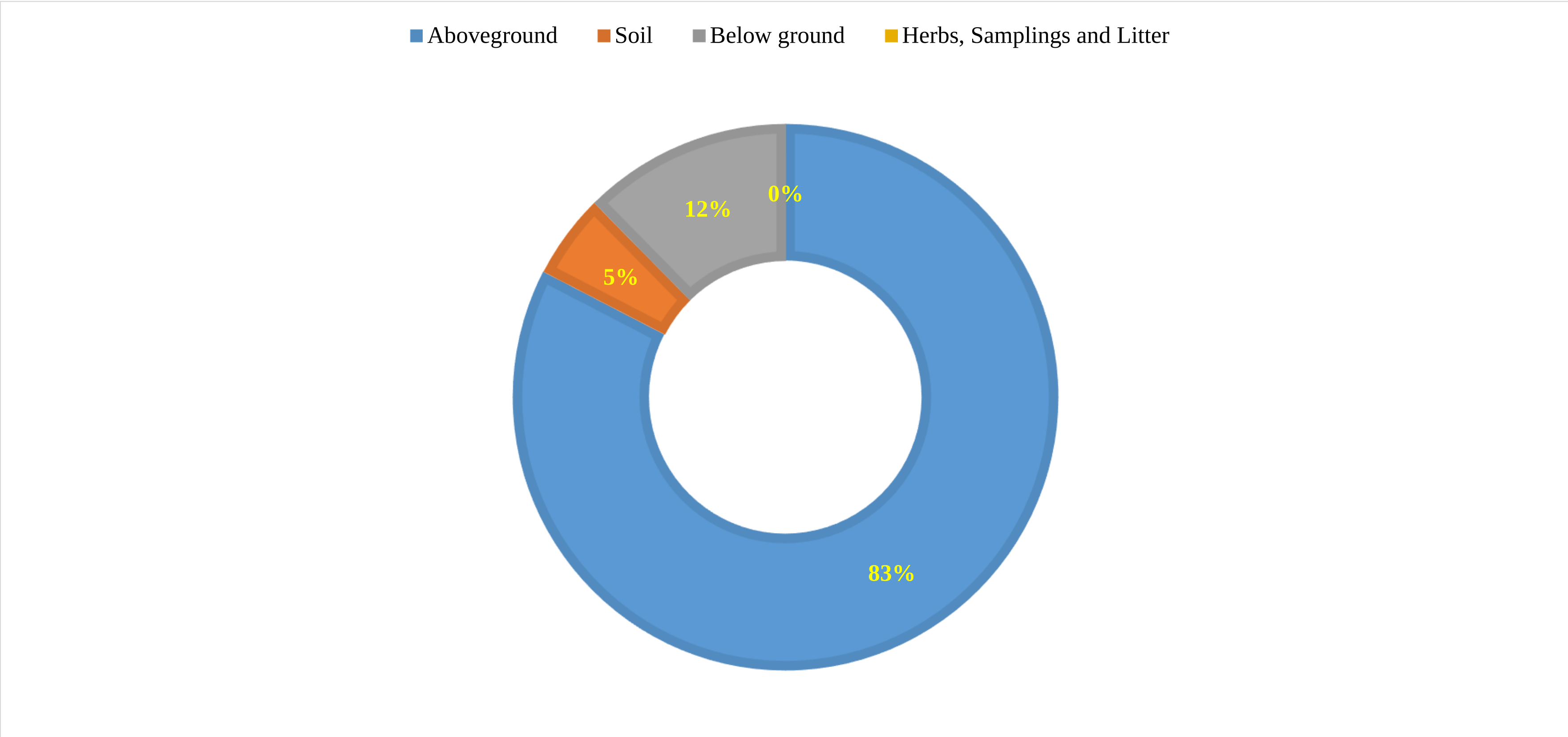

Figure 4.7: Ibodi carbon sequestration potential in different pools ($t.CO_2e.ha^{-1}$)

CHAPTER FIVE

DISCUSSION

5.1 Floristic composition of Ibodi monkey forest

The forests of the world carried out a germane role in maintaining and balancing the natural ecosystem. The forest and its resources fulfill human obligations and demands by providing renewable raw materials and energy, maintain biodiversity and protect land and water resources. The study of the forest flora and its structure are sine qua non in understanding the value and importance of forest (Komolafe *et al*., 2017).

In the current study, herbaceous species varied across the three physiognomies studies. Herbaceous species encountered accounts for 23.60 % of the whole flora of the forest. There were more herbaceous species in the TF than any other two physiognomies. This indicates open canopies in this physiognomy due to the practice of shifting cultivation in the area which enables the herbaceous species to thrive due to light availability. This corroborates with the study of Borgmann *et al.* (2005) and Johnson (2016) that opined that anthropogenic interferences result in greater ecosystem fragmentation and disturbances, allowing for the greater establishment of invasive herbaceous species. Fragmentation increases light availability. However, the study reported that herbaceous species in the RF were few which might be due to a lesser intensity of anthropogenic activity compared to the other two physiognomy (Komolafe *et al.,* 2017). Furthermore, common herbaceous species such as *Chromolaena odorata, Cyathula prostrata, Melenthera scandens, Phaulopsis falcisepala, Pouzolzia guineensis* have been reported to be an invasive species, a weed of cultivated land, of waste places and forest margins (Fuke *et al.,* 2016; Olowokudejo and Oyebanji, 2016; Komolafe *et al.,* 2017; Rembold *et al.,* 2017). *Chromolaena odorata* specifically has been reported to be an obnoxious weed that invades plantations, regrowth forest and cultivated agricultural areas competing and interfering with crop-growth (Akinbiola *et al.*, 2016)

The number of individual woody species varied notably across all the three physiognomies in the study area. Woody species encountered accounts for 51.8 % of the whole flora in the forest. The study recorded more woody species in the RF than other two physiognomies in the study area. This indicates that the intensity of interferences was more severe at CP and TFF than the RF. This may be due to the fact that both physiognomies are located at fringes of the forest whil e RF quite secluded away from human habitation. These findings agree with Htun *et al.* (2 013) and Aye *et al.* (2014) that opined that forest cover loss was high in areas close to park boundaries and roads and low in remote and less accessible areas. *Albizia zygia, Alchornea laxiflora, Antiaris toxicaria, Cnestis ferruginea, Elaeis guineensis, Ficus exasperata, Lecaniodiscus cupanioides, Newbouldia laevis, Oxytenanthera abyssinica, Sterculia tragacantha, Voacanga africana* were woody species common to the three physiognomies. *Elaeis guineensis* was specifically present in the RF indicating human interference (Salami, 2001; Akinbiola *et al.*, 2016) and a suggestion of previous landuse of the physiognomy.

Climbers, Epiphytes, ferns and Grass species accounted for 25.10 % of the whole flora in the forest. Tree Fallow physiognomy has the highest number of species when compared to the other two physiognomies. This might be due to the age of the forest. Lianas (woody climbers) are significantly more abundant in young regrowth secondary forests (≤ 40 years old) than in older forests (≥ 100 years-old) (Dewalt *et al.*, 2000; Kuzee and Bongers 2005) which may affect tree recruitment, growth rates, fecundity and survival, as well as alter the successional trajectories of gap-phase regeneration (Stevens 1987; Clark & Clark 1990; Pérez-Salicrup and Barker 2000; Schnitzer *et al.*, 2000).

The dominant families in the study area includes Euphorbiaceae (13 species), Moraceae (12 species), Apocynaceae (11 species), Papilionaceae (9 species), Asteraceae and Rubiaceae (8 species), Cucurbitaceae and Sterculiaceae (7 species), Acanthaceae, Malvaceae, Sapindaceae (6 species) and, Mimosaceae (5 species). The dominance of these families is consistent among different lowland tropical rain forest region (Aye *et al.*, 2014; Bogale *et al.*, 2017; Rita and François, 2018; Salami and Akinyele, 2018)

5.2 Vegetation structure of Ibodi monkey forest

5.2.1 Species richness, diversity, and evenness among the three physiognomies

The combination of a number of species and their relative abundance determines species diversity. The values of species diversity depend upon levels of species richness and evenness (Manuel and Molles, 2007; Bogale *et al.,* 2017)

The result of tree species classification and biodiversity indices (Shannon-Weiner diversity, and evenness index and Margalef's Species Richness index) in the three physiognomies shows that RF is more diverse and has a higher level of richness followed by CP and TF. The variance in the species classification and biodiversity indices of the three physiognomies might be probably due to the difference in their species composition, level of disturbance involved (like selective exploitation of economic species, fuelwood gathering, and construction). In addition agricultural expansion, illegal settlement, overgrazing, artisan mining and shifting cultivation are also major problems of the study area (Bogale *et al.,* 2017)

5.2.2 Sorensen index of similarity among the three physiognomies

The result of Sorensen's index of similarity was used to determine the similarities among plant communities. There was high similarity among the three physiognomies, with similarities highest between CP and TF most importantly in terms of proportion of species common to the physiognomies. This could be a consequence of the geographic proximity or closeness of the sites, which are separated by short distances (Santos *et al.,* 2015). Furthermore, this probably could be linked to anthropogenic and other environmental factors such as soil type and properties. However, a small number of habitat tree species may contribute to marked divergences in the species composition of adjacent communities. This may account for the reduced similarity observed between the RF and the other two physiognomies (Santos *et al.,* 2015).

5.2.3 Woody species density

The highest of woody density species was found in the RF and the least in the TF. This pattern is consistent with the regime and intensity of disturbance in the three difference physiognomies in the study area. There were selective logging of mature timber species in the CP and intensive artisan mining regime in TF which has affected the woody species in both physiognomies in no small measure.

The dominant species in terms of density are *Trichilia prieureana*, (92 species per hectare) of the family Meliaceae, *Lecaniodiscus cupanioides*, (60 species per hectare) in the family Sapindaceae and *Diospyros* sp (56 species per hectare) in the family Ebenaceae have been reported to be a prominent species in the Nigerian rainforest (Were, 2001; Salami and Akinyele, 2018). There were thirty woody species found (with dbh ≥10cm) in all the three physiognomies with less than 10 individuals per hectare namely; *Albizia ferruginea, Alchornea cordifolia, Alstonia boonei, Canthium sp, Carpolobia lutea, Ceiba pentandra, Celtis sp, Chrysophyllum albidium, Citrus sinensis, Cola millenii, Cordia sp, Deinbollia pinnata, Diospyros barteri, Dracaena manii, Khaya grandifoliola, Monodora myristica, Morinda lucida, Myrianthus arboreus, Napoleonaea vogelii, Newbouldia laevis, Pentaclethra macrophylla, Rauvolfia vomitoria, Sterculia rhinopetala, Sterculia tragacantha, Strombosia pustulata, Trichilia monedelpha, Triplochiton scleroxylon, Vitex doniana, Voacanga africana,* could be endangered in the study area due to persistent interferences on the forest. (Ihenyen *et al.*, 2010; Aigbe *et al*., 2017)

5.2.4 **Basal Area (m^2ha^{-1}) distribution**

The basal area obtained in this study (33.00 m^2ha^{-1}) was lower than 86.50 $m^2.ha^{-1}$ reported by Salami and Akinyele (2018) in Omo biosphere reserve, Ogun State, Nigeria. However, the value is higher than the value reported by Alder and Abayomi (1994), for a well-stocked tropical rainforest in Nigeria with an average basal area of 15.00 m^2ha^{-1} though significantly lower than the 64.90 $m^2.h^{-1}$ obtained by komolafe *et al*., (2017) for the same study area. When compared to other basal area reported in Africa, it is reasonably higher than the value of 18.5 $m^2.h^{-1}$ reported by Birhanu *et al.,* (2018) for Amoro Forest in West Gojjam Zone, North Western Ethiopia and close to the value of 21.05 m^2 ha^{-1} obtained by Hakizimana *et al*., (2016) for Kibira rainforest, Burundi. This differences reported in the current study is to be expected since the study is not under protection by any forest guard. The report that RF has the highest mean basal area (17.96 $m^2.ha^{-1}$) among the three physiognomies shows that the RF is more mature than other physiognomy types in Ibodi Monkey Forest with a less human disturbance in the area. Tree Fallow has the lowest mean basal area (1.93 $m^2.ha^{-1}$) with the CP having an intermediate mean basal area (13.12 $m^2.ha^{-1}$). The low basal area could be attributed to the degree of disturbance, which affect species composition, age structure, and successional stage of the forest. (Hakizimana *et al*., 2016).

5.2.5 Family Important value index (FIVI)

The FIVI is an indicator of families that are important in the floristic composition of a vegetation. Some of the dominant families in this study (Sterculiaceae, Euphorbiaceae, Apocynaceae, and Meliaceae) have been reported by Onyekwelu *et al*., (2008) as dominant tree species in three rainforest ecosystems in southwestern Nigeria. The findings of this study corroborates the findings of Adekunle *et al.* (2013) who reported one or more of the dominant families in this study as dominant in Strict Nature Reserve, within Akure Forest Reserve in Ondo State, Southwest, Nigeria.

5.3 Temporal changes in the floristic composition and structure of Ibodi Monkey Forest

5.3.1 Temporal changes in the floristic composition of Ibodi Monkey forest

The forest and its resources in most African countries are threatened by various natural and most importantly anthropogenic disturbances, such as exploitation of economic species, land use changes, overexploitation of non-timber forest products, and agriculture. The challenge of unsustainable use of forest and its resources in Nigeria is of growing concern and this was evident in the study of Komolafe *et al*. (2017).

The total number of individual species in all the three physiognomies in the study increased by 17.2% over a five year period and an average of six (6) new individual species being introduced to the forest annually. This is significant and indicates that the site is undergoing rapid and intense environmental changes because of human actions such as logging, agriculture expansion, land use change, construction, and artisanal mining. For example, logging was found to be the prevailing factor influencing the establishment of alien plants in a national park in Madagascar and due to the dominance and tenacity of the invasive species, the logged sites never regained native species diversity (Brown and Gurevitch, 2004, Chaudhary, A. *et al.,* 2016).

The number of individual woody species increased by 6.5% over the time period of the two studies. It must be noted, however, that there was a 5% decrease in the number of species in the RF while an increase of 53.8% and 22% in CP and TF, respectively. The decrease in the species in the RF may be due to anthropological influences while the increase in the other two physiognomies might be due to the openness of their canopy to foreign seeds and propagules (Komolafe *et al.,* 2017). It has been noted in a similar temporal study by Maracahipes-Santos *et al.,* (2018) that the changes observed in the present study occurred over a period of five years, which is considered a short-term scale for woody vegetation in the tropics. The number of individual herbaceous species encountered in comparison with the baseline data indicated there was a 36.40% increase. Changes in the RF in terms of herbaceous species indicates an 83.30% increase in the number of herbaceous species in the physiognomy and approximately a new herbaceous species invading the physiognomy in the past 5 years, this indicates that the level of interferences that occurred in the past 5 years allowed invasive species such as *Chromolaena odorata* (common to the three physiognomies understudy) to invade the physiognomy (Fuke *et al.,* 2016; Olowokudejo and Oyebanji, 2016). Furthermore, 35.30% increase observed in the CP and 68.40% increase in new species observed within 5 years in the TF could be attributed to the past and present disturbances that have led to a considerable decrease in closed canopy of woody species.

These levels of alteration and interferences of species composition affects the future eco system balance, resilience, and sustainability. This corroborates the assertion of Swamy et *al.* (2010) who stated that many tropical forests have an immense innate capacity for self-
subsistence though many of them are losing this ability due to excessive biotic interfer ences such as anthropogenic disturbances.

An increase of 29.70% was observed in the number of individual climber epiphytes, fe rns and grass species in the study area. There was a 72.70% increase in the number of s pecies in RF an average of two new species invading the physiognomy in the past 5 ye ars. This might be as a result of gaps created through selective exploitation of timber w oody species in this physiognomies. It has been reported that many canopy gaps beco me colonized by lianas (woody climbers) very soon after gap formation (Schnitzer and Carson 2001; Schnitzer *et al.,* 2004).

5.3.2 Temporal changes in the forest structure of Ibodi Monkey forest

5.3.2.1 Temporal changes in the tree Species Classification and Biodiversity Indices

There was an 11.25% decrease in Shannon-Weiner diversity index (SDI) value in the RF when compared with the baseline data, however, there was a huge decrease in the SDI value in CP and TF with a percentage decrease of 84.57% and 90.99% respectively. The reason for the relatively lower drop in RF SDI value compared to the may be due to the relatively restricted access to the physiognomy. However, the steep decrease in the SDI value in both CP and TF could be explained by the extensive anthropological interferences by the farm owners and the rural populations in the study area. Group of woody plant species is usually cut or burnt for agricultural, social, economic and cultural purposes by local populations. (Rita and François, 2018).

Species richness index (SRI) shows a 44.18% decrease in the RF over the 5 year period after Komolafe *et al*. (2017). Moreover, a decrease of 87.27% and 93.85% was observed in CP and TF respectively. The steep temporal change in SRI over the 5 year period observed in all the physiognomies shows that there was variation or change in the plant species composition over time (Olatunji *et al.,* 2015). Furthermore, Olatunji *et al.* (2015) reported SRI is related to the level of disturbance in the forest, this explains the low decrease in SRI value in the RF when compared with CP and TF.

The Species Evenness Index (SEI) for the forest is indicative of high species distribution and the evenness of species. (Onyekwelu *et al*., 2008; Salami and Akinyele, 2018). This may be a function of the level of interferences and disturbances in the area. This supports the observation of this study that temporal changes in the SEI was responsible for the decrease with percentage SEI decreasing in order of RF<CCP<TF. This furthermore, corroborated the report of Lalfakawma *et al.* (2009), who opined that undisturbed site achieved highest equability or evenness than the disturbed site in their

study of community composition and tree population structure in undisturbed and disturbed tropical semi-evergreen forest stands of north-east India.

The temporal change in the Sorensen's similarity index (SSI) indicates that there was an increase in similarity in the three physiognomies over the past 5 years. There was low similarity specifically between RF-CP (21.11%) and RF-TF (16.54%) five years ago. This might be due but not limited to land use change in the study area. This supports Chaudhary *et al*. (2016) that reported that Sørensen's similarity index that may be more sensitive to land use impacts than relative species richness. Other factors of influence include the variation in species composition and diversity among communities which could be associated with different factors, such as altitude, anthropogenic impacts, soil properties, slope, and aspect. (Bogale *et al*., 2017)

5.3.2.2 Temporal changes in woody species density

There was more than a 100% decrease in the density of woody species in the study area per hectare. In the RF, the density of species per hectare reduced from 1483 to 484, 1072 to 292 in CP and 792 to 176 in the TF. Land use changes and logging are two major factors that might be responsible for this high decline in the density of species. (Htun *et al.,* 2013). However, Houehanou *et al.* (2012) and Pereki *et al.* (2013) pointed out that bushfire and breakage might have significant negative influence on woody species density particularly in lower layer, other factors include differences in condition of each physiognomy in the study site over the period of study, species characteristics for adaptation, degree of exploitation, conditions for regeneration (Shibru and Balcha, 2004) and a wider distribution of the species in the forest. (Birhanu *et al.,* 2018)

5.3.2.3 Temporal changes in the basal area

The Mean Basal Area (MBA) of the study site reduced from 64.90 m^2ha^{-1} to 33.01 m^2ha^{-1} over the 5 year period after Komolafe *et al.* (2017). The major decrease was in the RF with 56.10% decrease and 38.81% and 24.31% in CP and TF. This trend indicates that study sites are now dominated by shrubs and saplings. Furthermore, cutting down trees and other factors influenced species by reducing the number of stems, affecting species diversity and the size of species. (Birhanu *et al.,* 2018)

5.4 Carbon stock and sequestration potential in Ibodi Monkey forest

5.4.1 Soil Organic Carbon (SOC), Nitrogen (N), Organic matter (OM) in Ibodi monkey forest

Soil organic carbon was observed to be relatively high in the surface layers of the soils of the three physiognomies. However, the highest organic carbon was found in the Regrowth Forest physiognomy (RF), while the least was found in the TF. This can be attributed to a number of factors such as high litter input by the forest (Pinheiro *et al*., 2017) and dead soil fauna in the regrowth physiognomy. Decomposition of litterfall, slashed undergrowth and decayed cacao pods especially at the soil surface were responsible for increase in SOC in the Cocoa plantation physiognomy. It is at the soil surface that most biological activity is concentrated (Banwart *et al*., 2014; Gideon *et al*., 2016).

The percentage organic carbon in the three physiognomies of this study reasonably low with values ranging from 2.25% to 3.29% but values as high as 4.63% have been reported for surface soils with content decreasing with depth. (Enwezor *et al*., 1981; Gideon *et al*., 2016) However, low organic carbon content has been reported by Ufot *et al*., 2016 (1.03%) in their study of effects of land use on soil physical and chemical properties in Akokwa Area of Imo State, Nigeria, also Gideon *et al*., 2016 (1.63%) in three land use systems in Abia State, Nigeria. However, the value of 2.60% reported by Agboola (2017) for the tropical moist forest of Osun State is in agreement with this study.

Nitrogen content was observed to be highest in the RF and TF has the least N. The value of Total N in the study area which ranged between 0.21% and 0.29% was close to 0.31% N reported for Nigerian forest soils by Onyekwelu *et al*. (2008). However, it is significantly lower than plant sufficiency range (1 and 6%) in soils (Gideon *et al*., 2016). The higher total N in the RF soil maybe due to microbial mineralization of organic residues, especially litter fall (Gideon *et al*., 2016). There was a general decrease in Total N with depth from 0 - 15 cm to 45-60 cm, this might be due to diminishing humus with depth. (Gbadegesin *et al*., 2012; Ufot *et al*., 2016)

Soil organic matter (SOM) dynamics are directly proportional to plant inputs such as leaf litter and root products. In this study, Soil Organic Matter (SOM) was highest in the RF and was the least TF. This might be as a result of the level of disturbances in each of the physiognomy understudy (Arévalo-Gardini *et al.,* 2015). Losses of SOM in the TF could be attributed to rapid mineralization following previous cultivation which disrupts soil aggregates, and thereby increases aeration and microbial accessibility to SOM (Solomon *et al.,* 2000; Solomon *et al.,* 2002).

5.4.2 Soil Carbon Stocks in Ibodi monkey forest

The soil carbon stock is a balance of incoming carbon from organic matter and carbon losses either through decomposition processes or Dissolved Organic Carbon (DOC) le aching (Davidson and Janssens, 2006; Raich *et al*., 2006; Hombegowda *et al*., 2016). Soil Organic Carbon losses and gains reflect a change in the equilibrium of carbon inpu ts, losses in the present land uses and influence through other factors such as anthropol ogical interferences. (Van Straaten *et al*., 2015).

The total Carbon Stocks in three physiognomies in Ibodi Monkey forest (333.11 $t.h^{-1}$) was more than the average value stored in the whole soil profile of the mid-latitudinal belt of the world (96.00 $t{\cdot}ha^{-1}$), although it falls within the results obtained by Lal (2004) for soil carbon stock for tropical (121–123 $t{\cdot}ha^{-1}$), temperate (96–147 $t{\cdot}ha^{-1}$) and boreal forest ecosystems (247–344 $t{\cdot}ha^{-1}$). However, results obtained from this study was reasonably higher than the one obtained in riparian vegetation (61.23 $t{\cdot}ha^{-1}$) in Ile-Ife by Onome and Odiwe (2018). The dissimilarities might be a result of the several fa ctors such as sampling depths, the management history of the study sites, climatic, geo graphical, geological and environmental factors in the study sites. (Justine *et al*., 2015)

Regrowth Forest physiognomy (RF) (144.34 $t.h^{-1}$) had significantly higher soil carbon stocks than the two physiognomies with the Cocoa P lantation physiognomy (CP) (94.37 $t.ha^{-1}$) having the least soil carbon stocks. RF contributed the highest percentage (44.33%) to t he carbon stock pool in the study area implying that increase in RF will lead to increased ac cumulation of soil organic carbon in the pool. (Olorunfemi *et al*., 2019). Continuous remo val of standing litter crop via open canopies, dead wood and twigs, fuelwood gathering, char coal making, logging of merchantable species, forest clearing for agricultural artisan minin g are few human pressure that might be a confounding factor when analyzing the variation in soil carbon stock in Ibodi monkey forests (Girmay *et al*., 2008; Tesfaye *et al*., 2016).

5.4.3 Above ground Biomass and Carbon stock in the aboveground pool

Regrowth Forest physiognomy (RF) (441160.98 kgha^{-1}) had the highest aboveground biomass contributing 64.25% of total AGB in the study site, 26.89% and 8.86% in Cocoa plantation physiognomy (CP) (174042.21 kgha^{-1}) and Tree fallow Physiognomy TF (60815.01 kgha^{-1}), respectively. The total AGB in the study area decreased with increasing level of interference and disturbance peculiar to each site. Other factors, however, includes plant species and growth forms within spatial gradients, soil moisture, and edaphic conditions (Wang *et al.,* 2008).

Furthermore, more biomass is contained in aboveground carbon pool than in other carbon pool. (Olorunfemi *et al.,* 2019). The AGB pool accounted for 82.60% of the total biomass of the study area.

One important finding of this work was the significantly higher aboveground carbon stock in the RF compared to other physiognomies even though all three physiognomies are exposed to equally intensive interferences, the high number of large trees in RF still gave the physiognomy a significantly higher aboveground carbon stocks. The obvious difference in the aboveground carbon stock of RF compared to other physiognomies is due to greater production of biomass in the forest trees. The differences in aboveground carbon storage among different physiognomies in this study reveals variation in a number of factors peculiar to different physiognomies across the study site namely tree structure, the regime of disturbance history, management practices and soil fertility (Ngo *et al*., 2013; Olorunfemi *et al*., 2019). Low biomass and carbon stocks observed in the TF might be due to loss of carbon resulting from the removal of vegetation. (Conti *et al*., 2014).

5.4.4 Carbon stock in the herbs, shrubs and litter pool

The carbon stock recorded in the litter, herbs and saplings was 0.1488 t.C.ha^{-1} in all the three physiognomy, this falls within the values reported for some other tropical forests in various parts of the world (>1 to > 30 t.C.ha^{-1}) (Barker *et al*., 2007; Yang *et al*., 2010). Moreover, the value was reasonably close to the range obtained by Ogunsanwo (2016) (0.03-0.11 t.Cha-1) along the riparian corridor in Ile-

Ife, South western Nigeria and less than the estimate of Onome and Odiwe (2018) (2.13 - 4.25 t.C. ha^{-1} (shrubs and herbs) and 5.83 – 25.44 t.C. ha^{-1} (standing litter) for forest vegetations in Obafemi Awolowo University, a tropical rainforest ecosystem, southwest, Nigeria.

5.5 Carbon sequestration potential

Ibodi monkey forest has the capacity of storing up to 6650.13 t.ha^{-1} of C with the carbon sequestration potential of 24386.02 t.CO_2e.ha^{-1}. Reports on the tropical forest have put the range of soil C storage between 90 - 200 t C/ha (Amundson, 2001; Lewis *et al.*, 2009). The result obtained in this study for SOC (1221.51 t.CO_2e.ha^{-1}) was reasonably higher than the range for the tropics. Nair (2012) has also reported sequestration of biomass carbon in the range of 3–18 t C ha^{-1} on cultivated land, this range was lower to the sequestration potential for the Tree Fallow (TF) physiognomy (1784.07 t.CO_2e.ha^{-1}) where some form of cultivation is going on. The forest has the potential in mitigating climate change by sequestering huge volume of CO_2 equivalents if well managed. However, Nigeria, being a developing country has the challenge of deforestation, forest degradation and land use/land cover change which culminate into high carbon emissions.

CHAPTER SIX

SUMMARY AND CONCLUSION

6.1 Summary

Quantification of vegetation structure, floristic composition, and temporal changes from the baseline data showed remarkable changes over time and in the three different physiognomies. The intensity of disturbance in the study area showed a subtle change of RF to TF through logging, agriculture artisan mining, and erection of buildings. This led to a 17.2% increase in the number of individual species over the five year and an average of six (6) new individual species being introduced to the forest annually, species are mostly herbaceous species and saplings. Moreover, the structure of the forest has been disturbed with diversity index value reduced by 11.25% in the RF in a 5 year period, with reduction as high as 90.99% in the TF. Also, evaluation of the temporal changes in Sorensen similarity index (SSI) value among the three physiognomies shows that RF has become more similar to the CP and TF.

One major finding of the current study was that carbon stocks under different physiogno mies in Ibodi Monkey forest, southwestern Nigeria indicates a varying differences am ong the three physiognomies. Regrowth forest physiognomy had greater biomass and t otal carbon stocks than the other two physiognomies (Cocoa plantation physiognomy a nd Tree fallow physiognomy). A baseline overall estimate of carbon stock and sequestr ation potential carbon sequestration potential of Ibodi Monkey forest was 6650.13 t.C. ha^{-1} and 24386.02 $t.CO_2e.ha^{-1}$ respectively.

6.2 Conclusion

The outcome of this result proves there is rich biodiversity and higher carbon accumulation within the regrowth forest. However, less species and biodiversity recorded within the two most disturbed physiognomies (CP and TF) reveals the extent to which disturbance can impact negatively on the potential of Ibodi Monkey forest to be an effective Carbon sink. The sequestration potential estimated indicates the forest still has the potential to p lay a role in the global climate change mitigation.

6.3 Recommendations

In other to improve and sustain the forest carbon storage potential, it is pertinent that urgent management practices that sequester carbon is introduced to mitigate and arrest the pe nding destruction of the remaining carbon pool in the study area. This might include e mploying a forest guard and also proper demarcation of the boundaries of the forest to limit encroachment by villagers. Furthermore, sensitization outreaches should be imple mented to create awareness on the imperative of forests, to give the villagers better un derstanding on how forests work and why they are important to change their opinion s o that they can appreciate the use and potentials of the forest.

6.4 Contribution to knowledge

This study provides the baseline information on the carbon sequestration potential of different physiognomies in Ibodi monkey forest and the forest as a who le. The study supplies information on the species of the forest which can play in a vital role in the mitigation of climate change. Furthermore, the study provides data on which proper management Strategies and plans can be made to salvage the biodiversity of Ibodi Monkey Forest.

Futher studies should be conducted on the temporal changes in both species compositon and carbon stocks to ensure proper monitoring of the effectiveness of the management programs recommended.

6.5 Suggestions for futher studies

Futher studies should be conducted on the temporal changes in both species compositon and carbon stocks to ensure proper monitoring of the effectiveness of the management programs recommended. Due to the anthropogenic activities in the study, the endemic monkey species have moved deeper in the regrowth forest, a study of their habitat range will be highly useful. Artisanary mining have impacted the soil, flora and fauna of several part of the forest, The effect of gold mining is recommended to determine if any the environmental impact on the forest soil, flora and fauna.

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APPENDIX

APENDIX 1.1

The Extent of Ibodi monkey forest

Regrowth forest Physiognomy in Ibodi Monkey Forest

Tree fallow Physiognomy in Ibodi Monkey Forest (Arable crops and woody species such as *Gliricidia sepium*)

Cocoa plantation Physiognomy in Ibodi Mokey Forest

Forest signpost at the entrance of Ibodi Monkey Forest

APENDIX 1.2

STATISTICAL ANALYSIS FOR THE TEMPORAL CHANGES IN SPECIES COMPOSTION

Descriptive Statistics

Descriptive summary of the overall species level across sites

Statistics	*RF*	*CP*	*TF*
2013	33±27.0	21.5±4.50	30±11.0
2017	29±14.19	28.67±5.67	35.67±7.45

Graphically, the number of species found in 2017 is higher compare to what was found in 2013 at the three sites. Specifically, at site RF, we observe a 10.10% increase in the number of species between 2013 & 2017. There is 53.70% and 29.30% increases at site CP and TF respectively. Thus, the most significant change in the number of species presence at any site is observed at CP site.

We consider the species presence or variation by sites and across the years.

Descriptive summary of the species level across the Year

	2013			**2017**		
Statistics	**Woody**	**Herb**	**Climber**	**Woody**	**Herb**	**Climber**
Mean± SE	42.3±9.84	14±4.04	14.3±2.85	49±4.93	22±6.08	22.3±1.76
Maximum	60	19	20	57	32	25
Minimum	26	6	11	40	11	19
Range	34	13	9	17	21	6

We observe that, only the woody species at site RF reduces between year 2013 and 2017. Other species increases in number at all the three sites between 2013 and 2017.

Statistical Test (ANOVA)

Base on the stated objectives and the data supplied, we conduct Analysis of Variance (ANOVA). The following hypothesis will be tested.

Hypothesis one

H_0: There is no significant differences in the level or presence of species between 2013 and 2017 across the three sites.

H_1: There is significant differences in the level or presence of species between 2013 and 2017 across the three sites.

At the level of significance (α) = 5%.

The hypothesis above is testing whether the volume of species varies significant from one year (2013) to another (2017). Since, we are interested in observing the variation across species and within the year under study. We conduct a randomized completed block design (RCBD), generally known as two-way ANOVA test.

Result of the ANOVA test for hypothesis

Sources of variation	**Degree of freedom**	**Sum of squares**	**Mean square**	**F**	**Pr(>F)**
Species	2	9076	4538	1702	0.000587***
Year	1	771	771	289	0.00344**
Residual	2	5	3		

The ANOVA test is significant. Thus, there is adequate evidence to reject the null hypothesis. This means that, there is significant differences in the level or presence of species between 2013 and 2017 across the three sites. That is, the number of species varies significantly from one year (2013) to another (2017). As a result, we must further conduct a Post Hoc test in order to measure the level of species variation across the years under consideration.

Post Hoc Test for Hypothesis one

The Post Hoc result reveals that, significant variation exist in the volume of woody species & climber species as well as between woody species & herb species from 2013 & 2017. Thus, woody species and climber species in 2017 across the three sites varies significantly higher compare to the woody species volume observed in 2013. Similarly, woody species and herb species also significantly varies within the years. Thus, for instance, the volume of woody species varies significantly different form climber species from one year to the other year.

Post Hoc test for hypothesis one

	Diff	lwr	upr	p adj
herb-climber	-1	-10.61956	8.619559	0.8288576
woody-climber	**82**	**72.38044**	**91.619559**	**0.0000101**
woody-herb	**83**	**73.38044**	**92.619559**	**0.0000085**
2017 - 2013	**22.67**	**16.93**	**28.40**	**0.00306**

Thus, the bolded row is the pair of species where significant differences exist.

Hypothesis two

In similar sense, we also wish to test whether the volume of each species varies significantly from one site to another within the 2013 and 2017. In order to achieve this, we consider the species volume in the first year across the sites and also did the same for the second year.

H_0: There is no significant differences in the volume of the species from one site to another within the 2013 and 2017.

H_1: There is significant differences in the volume of the species from one site to another within the 2013 and 2017.

The ANOVA test shows that, there is no significant differences in the volume of the species from one site to another in 2013 (see Table 4.5.1). That is, woody species at site one (RF) does not varies significantly from woody species at another site (CP). And, the woody species at any of the sites does not varies significantly from the climber or herbs species at any other sites under consideration. Generally, we can infer that, the species volume in 2013 is the same across the three sites under consideration.

Result of the ANOVA test for hypothesis two (2013)

Sources of variation	**Df**	**Sum of squares**	**Mean square**	**F**	**Pr(>F)**
Species	2	1586.9	793.4	5.262	0.0758
Sites	2	124.2	62.1	0.412	0.6876
Residual	4	603.1	150.8		

The ANOVA test shows that, there is significant differences in the volume of the species 2017 but the volume of various species does not varies significantly across the sites. That is, woody species at site one (RF) does not varies significantly from woody species at another site (CP). However, the volume of species varies significantly in 2017. Generally, we can infer that, the species volume in 2017 varies significantly but the same across the three sites under consideration.

This led us to the Post Hoc analysis on the species to identify which species varies significantly from the other.

Result of the ANOVA test for hypothesis two (2017)

Sources of variation	**Df**	**Sum of squares**	**Mean square**	**F**	**Pr(>F)**
Species	2	1440.2	720.1	9.827	0.0286*
Sites	2	93.6	46.8	0.638	0.5746
Residual	4	293.1	73.3		

Post Hoc Test for Hypothesis two

The Post Hoc result reveals that, significant variation exist in the volume of woody species & climber species as well as between woody species & herb species across the sites.

Post Hoc test for hypothesis two

	Diff	**lwr**	**upr**	**p adj**
herb-climber	-0.3333	-25.2435	24.5769	0.9987
woody-climber	**26.667**	**1.75649**	**51.5769**	**0.0404**
woody-herb	**27.000**	**2.0898**	**51.9102**	**0.0388**

Thus, the bolded row is the pair of species where significant differences exist.

APENDIX 1.3

STATISTICAL ANALYSIS FOR DETERMINATION OF SUITABLE ALLOMETRIC EQUATION FOR THE ESTIMATION OF ABOVEGROUND BIOMASS IN THE THREE PHYSIOGNOMY (MULTIPLE REGRESSION ANALYSIS)

REGROWTH FOREST PHYSIOGNOMY

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000[a]	1.000	1.000	89.1225692153

a. Predictors: (Constant), FELDPAUSCH, CHAVE2014, DJOMO, HENRY

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	27475553689.256	4	6868888422.314	864790.811	.000[b]
	Residual	246227.803	31	7942.832		
	Total	27475799917.059	35			

a. Dependent Variable: CHAVE2005

b. Predictors: (Constant), FELDPAUSCH, CHAVE2014, DJOMO, HENRY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	18.680	21.817		.856	.398
	HENRY	.042	.012	.018	3.396	.002
	DJOMO	.066	.034	.005	1.954	.060
	CHAVE2014	1.078	.004	1.007	256.078	.000
	FELDPAUSCH	-.263	.035	-.032	-7.577	.000

a. Dependent Variable: CHAVE2005
(F(4, 31)=864790.811), $p<0.05$, $R=1.000^3$, $R^2=1.000$)

(F (4, 31) = 864790.811), $p<0.05$, $R=1.000^3$, $R^2=1.000$)

The summary of analysis in the tables above suggest that HENRY, CHAVE2014 AND FELDPAUSCH jointly predict CHAVE2005 (F (4, 31) = 864790.811), $p<0.05$, $R=1.000^3$, $R^2=1.000$). Further investigation from the table indicates that 100% of variation is explained by the independents variables (HENRY, DJOMO, CHAVE2014 AND FELDPAUSCH). From the coefficient table HENRY (β= .042, t=3.396, $p<0.05$), DJOMO (β= .066, t=1.954, $p>0.05$), CHAVE2014 (β= 1.078, t=1.007, $p<0.05$), FELDPAUSCH (β= -.263, t=-.032, $p<0.05$). HENRY, FELDPAUSCH and CHAVE2014 independently predict CHAVE2005.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	1.000[a]	1.000	1.000	82.6548735532	1.000	877358.833	4	31	.000

a. Predictors: (Constant), CHAVE2005, DJOMO, FELDPAUSCH, HENRY

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	23975859000.510	4	5993964750.127	877358.833	.000[b]
	Residual	211786.672	31	6831.828		
	Total	23976070787.182	35			

a. Dependent Variable: CHAVE2014

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-17.884	20.218		-.885	.383
	HENRY	-.038	.012	-.017	-3.241	.003
	DJOMO	-.059	.032	-.005	-1.856	.073
	FELDPAUSCH	.241	.033	.032	7.342	.000
	CHAVE2005	.927	.004	.993	256.078	.000

a. Dependent Variable: CHAVE2014

(F (4, 31)= 877358.833), $p<0.05$, $R=1.000^3$, $R^2=1.000$)

The summary of analysis in the table above suggests that HENRY, CHAVE2005 AND FELDPAUSCH jointly predict CHAVE2014 (F (4, 31)= 877358.833), p<0.05, R=1.0003, R2=1.000). Further investigation from the table indicates that 100% of variation is explained by the independents variables (HENRY, DJOMO, CHAVE2005 AND FELDPAUSCH). From the coefficient table HENRY (β= -.038, t=-3.241, p<0.05), DJOMO (β= -.059, t=-1.856, p>0.05), CHAVE2005 (β= .927, t=256.078, p<0.05), FELDPAUSCH (β= .241, t=-7.342, p<0.05). HENRY, FELDPAUSCH, CHAVE2014 independently predict CHAVE2005. DJOMO is different because of the significant level which is higher than the rest.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.995[a]	.990	.989	1246.3151831956	.990	1066.614	3	32	.000

a. Predictors: (Constant), FELDPAUSCH, CHAVE2005, DJOMO

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	4970320060.816	3	1656773353.605	1066.614	.000[b]
	Residual	49705649.148	32	1553301.536		
	Total	5020025709.964	35			

a. Dependent Variable: HENRY

b. Predictors: (Constant), FELDPAUSCH, CHAVE2005, DJOMO

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	337.617	298.959		1.129	.267
	CHAVE2005	.292	.018	.684	16.564	.000
	DJOMO	-2.252	.261	-.430	-8.635	.000
	FELDPAUSCH	2.437	.245	.701	9.947	.000
a. Dependent Variable: HENRY						

($F(3, 32) = 1066.614$), $p<0.05$, R=.995, R^2=.990)

Excluded Variables[a]						
Model		Beta In	T	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	CHAVE2014	-14.556[b]	-3.241	.003	-.503	1.183E-005
a. Dependent Variable: HENRY						
b. Predictors in the Model: (Constant), FELDPAUSCH, CHAVE2005, DJOMO						

The summary of analysis in the table above suggests that CHAVE2005, DJOMO AND FELDPAUSCH jointly predict HENRY ($F(3, 32) = 1066.614$), $p<0.05$, R=.995, R^2=.990). Further investigation from the table indicates that 99.0% of variation is explained by the independents variables (DJOMO, CHAVE2005 AND FELDPAUSCH). From the coefficient table CHAVE2005 (β= .295, t=10.564, $p<0.05$), DJOMO (β= -2.252, t=-8.635, $p<0.05$), FELDPAUSCH (β= 2.437, t=9.947, $p<0.05$). , FELDPAUSCH, DJOMO independently predict CHAVE2005. CHAVE2014 is excluded because the significant level is 0.003 which is also less than 0.05 but, FELDPAUSCH, DJOMO and CHAVE2005 have the same significant level which makes them predicting variables for HENRY.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.981[a]	.963	.959	462.9775379653

a. Predictors: (Constant), FELDPAUSCH, CHAVE2005, HENRY

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	176255595.758	3	58751865.253	274.095	.000[b]
	Residual	6859142.421	32	214348.201		
	Total	183114738.179	35			

a. Dependent Variable: DJOMO

b. Predictors: (Constant), FELDPAUSCH, CHAVE2005, HENRY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	251.038	104.191		2.409	.022
	CHAVE2005	.084	.014	1.026	6.038	.000
	HENRY	-.311	.036	-1.627	-8.635	.000
	FELDPAUSCH	.993	.055	1.497	17.923	.000

a. Dependent Variable: DJOMO

(($F(3, 32) = 274.095$), $p<0.05$, $R=.981$, $R^2=.963$)

Excluded Variables[a]

Model		Beta In	T	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	CHAVE2014	-19.533[b]	-1.856	.073	-.316	9.814E-006

a. Dependent Variable: DJOMO

b. Predictors in the Model: (Constant), FELDPAUSCH, CHAVE2005, HENRY

The summary of analysis in the table above suggests that CHAVE2005, HENRY AND FELDPAUSCH jointly predict DJOMO (F (3, 32) =274.095), $p<0.05$, R=.981, R^2=.963). Further investigation from the table indicates that 96.30% of variation is explained by the independents variables (HENRY, CHAVE2005 AND FELDPAUSCH). From the coefficient table CHAVE2005 (β= .084, t=6.038, $p<0.05$), HENRY (β= -.311, t=-8.635, $p<0.05$), FELDPAUSCH (β= .993, t=17.923, $p<0.05$). , FELDPAUSCH, HENRY and CHAVE2005 independently predict DJOMO. CHAVE2014 is excluded because the significant level is 0.73 which is greater than 0.05 but, FELDPAUSCH, HENRY and CHAVE2005 have the same significant level which makes them predicting variables for DJOMO.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.992[a]	.985	.983	444.5403370760

a. Predictors: (Constant), DJOMO, HENRY, CHAVE2005

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	409603737.303	3	136534579.101	690.908	.000[b]
	Residual	6323715.561	32	197616.111		
	Total	415927452.864	35			

a. Dependent Variable: FELDPAUSCH

b. Predictors: (Constant), DJOMO, HENRY, CHAVE2005

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-130.028	106.281		-1.223	.230
	CHAVE2005	-.077	.014	-.629	-5.589	.000
	HENRY	.310	.031	1.077	9.947	.000
	DJOMO	.916	.051	.608	17.923	.000

a. Dependent Variable: FELDPAUSCH

((F (3, 32) =690.908), $p<0.05$, R=.992, R^2=.985)

Excluded Variables[a]						
Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	CHAVE2014	19.975[b]	7.342	.000	.797	2.419E-005

a. Dependent Variable: FELDPAUSCH

b. Predictors in the Model: (Constant), DJOMO, HENRY, CHAVE2005

The summary of analysis in the table above suggests that CHAVE2005, DJOMO AND HENRY jointly predict FELDPAUSCH ((F (3, 32) =690.908), $p<0.05$, R=.992, R^2=.985). Further investigation from the table indicates that 98.50% of variation is explained by the independents variables (DJOMO, CHAVE2005 AND HENRY). From the coefficient table CHAVE2005 (β= -.077, t=-5.589, $p<0.05$), DJOMO (β= .916, t=17.923, $p<0.05$), HENRY (β= .310, t=9.947, $p<0.05$). CHAVE2005, HENRY and DJOMO independently predict FELDPAUSCH. CHAVE2014 is excluded because the significant level is 0.797 which greater than 0.05 but, HENRY, DJOMO and CHAVE2005 have the same significant level which makes them predicting variables for FELDPAUSCH.

CHAVE2014 and CHAVE2005 are both good from the result of the analysis. This is because, CHAVE2014 and CHAVE2005 have R^2 to be one and are both statistically significant

TREE FALLOW PHYSIOGNOMY

The summary of analysis in the table below suggests that Henry *et al*., 2010 AND Feldpausch *et al*., 2012 jointly predict Djomo *et al*., 2010 ((F (2, 46) =22455.946), $p<0.05$, R=.999[3], R^2=.999). Further investigation from the table indicates that 99.90% of variation is explained by the independents variables (Feldpausch *et al*., 2012 and Henry *et al*., 2010). From the coefficient table Feldpausch *et al*., 2012 (β= .655, t=30.884, $p<0.05$) and Henry *et al*., 2010 (β= .047, t=4.181, $p<0.05$). Henry *et al*., 2010 and Feldpausch *et al*., 2012 independently predict Djomo *et al*., 2010. Chave *et al*., 2014 and Chave *et al*., 2005 are excluded variables.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.999[a]	.999	.999	38.6477418286

a. Predictors: (Constant), Henry *et al*., 2010, Feldpausch *et al*., 2012

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	67082555.373	2	33541277.686	22455.946	.000[b]
1	Residual	68707.806	46	1493.648		
	Total	67151263.179	48			

a. Dependent Variable: Djomo *et al*., 2010

b. Predictors: (Constant), Henry *et al*, 2010, Feldpausch *et al*., 2012

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.485	5.641		.972	.336
	Feldpausch *et al*., 2012	.655	.021	.882	30.884	.000
	Henry *et al*, 2010	.047	.011	.119	4.181	.000

a. Dependent Variable: Djomo *et al*., 2010

(($F(2, 46) = 22455.946$), $p<0.05$, $R=.999^3$, $R^2=.999$)

Excluded Variables[a]

Model		Beta In	T	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	CHAVE ET AL., 2014	25.153[b]	167375.091	.000	1.000	1.617E-006
	CHAVE ET AL., 2005	23.666[b]	180532.399	.000	1.000	1.827E-006

a. Dependent Variable: Djomo *et al*., 2010

b. Predictors in the Model: (Constant), Henry *et al*, 2010, Feldpausch *et al*., 2012

The summary of analysis in the table below suggests that Djomo *et al*., (2010) and Chave *et al*., 2014 jointly predict Feldpausch *et al*., (2012) (($F(2, 46) = 18963.678$), $p<0.05$, $R=.999^3$, $R^2=.999$). Further investigation from the table indicates that 99.90% of variation is explained by the independents variables (Djomo *et al*., 2010 and Chave *et al*., 2014). From the coefficient table Djomo *et al*., 2010 ($\beta = 1.448$, $t=38.239$, $p<0.05$) and Chave *et al*., (2014) ($\beta = -.017$, $t=-2.760$, $p<0.05$). Djomo *et al*., (2010) and Chave *et al*., (2014) independently predict Feldpausch *et al*., (2012). Chave *et al*., (2005) and Henry *et al*, (2010) are excluded variables.

The result from the analysis shows that Djomo *et al*., (2010) and Feldpausch *et al*., (2012) is the best formula to use because the R^2 values are closer to one and they are both statistically significant.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.999[a]	.999	.999	56.6296604533

a. Predictors: (Constant), Chave *et al*., (2014), Djomo *et al*., (2010)

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	121629940.492	2	60814970.246	18963.678	.000[b]
	Residual	147518.248	46	3206.918		
	Total	121777458.740	48			

a. Dependent Variable: Feldpausch *et al*., (2012)

b. Predictors: (Constant), Chave *et al*., (2014), Djomo *et al*., (2010)

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-6.659	8.292		-.803	.426
	Djomo *et al*., 2010	1.448	.038	1.076	38.239	.000
	Chave *et al*., 2014	-.017	.006	-.078	-2.760	.008

a. Dependent Variable: feldpausch *et al*., (2012)

(($F (2, 46) = 18963.678$), $p<0.05$, $R=.999^3$, $R^2=.999$)

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000[a]	1.000	1.000	.0002716064

a. Predictors: (Constant), Feldpausch *et al.*, (2012), Chave *et al.*, (2014), Djomo *et al.*, (2010)

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2990076407.616	3	996692135.872	.	.[b]
	Residual	.000	45	.000		
	Total	2990076407.616	48			

a. Dependent Variable: Chave *et al.*, (2005)

b. Predictors: (Constant), Feldpausch *et al.*, (2012), Chave *et al.*, (2014), Djomo *et al.*, (2010)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.101E-010	.000		.000	1.000
	Djomo *et al.*, 2010	.009	.000	.001	8942.174	.000
	Chave *et al.*, 2014	1.085	.000	1.028	35352853.409	.000
	feldpausch *et al.*, 2012	-.149	.000	-.030	-213367.126	.000

a. Dependent Variable: Chave *et al.*, (2005)

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Henry *et al*, 2010	.[b]	.	.	.	.000

a. Dependent Variable: Chave *et al*., (2005)

b. Predictors in the Model: (Constant), Feldpausch *et al*., (2012), Chave *et al*., (2014), Djomo *et al*., (2010)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000[a]	1.000	1.000	.0001274470

a. Predictors: (Constant), Chave *et al*., 2005, Feldpausch *et al*., 2012, Djomo *et al*., 2010

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	438904522.210	3	146301507.403	.	.[b]
	Residual	.000	45	.000		
	Total	438904522.210	48			

a. Dependent Variable: Henry *et al*, 2010

b. Predictors: (Constant), Chave *et al*., 2005, Feldpausch *et al*., 2012, Djomo *et al*., 2010

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-7.280E-011	.000		.000	1.000
	Djomo *et al*., 2010	-.087	.000	-.034	-179814.383	.000
	Feldpausch *et al*., 2012	.433	.000	.228	1307096.180	.000
	Chave *et al*., 2005	.310	.000	.810	23208905.372	.000

a. Dependent Variable: Henry *et al*, (2010)

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Chave *et al*., 2014	.[b]	.	.	.	.000

a. Dependent Variable: Henry *et al*, 2010

B. Predictors In The Model: (Constant), Chave *Et Al*., 2005, Feldpausch *et al*., 2012, Djomo *et al.*, 2010

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000[a]	1.000	1.000	.0002442031

a. Predictors: (Constant), Djomo *et al.*, (2010), Chave *et al*., (2005), Feldpausch *et al*., (2012)

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2685728233.525	3	895242744.508	.	.[b]
	Residual	.000	45	.000		
	Total	2685728233.525	48			

a. Dependent Variable: Chave *et al.*, (2014)

b. Predictors: (Constant), Djomo *et al.*, 2010, Chave *et al.*, 2005, Feldpausch *et al.*, 2012

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-1.087E-010	.000		.000	1.000
	Feldpausch *et al.*, 2012	.138	.000	.029	212531.616	.000
	Chave et al., 2005	.922	.000	.973	35295068.161	.000
	Djomo *et al.*, 2010	-.008	.000	-.001	-8926.360	.000

a. Dependent Variable: Chave *et al.*, (2014)

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Chave *et al.*, 2005	-33.192[b]	-213083.559	.000	-1.000	1.100E-006

	Henry *et al*, 2010	4.909[b]	1121281.584	.000	1.000	5.027E-005

a. Dependent Variable: Feldpausch *et al*., (2012)

b. Predictors in the Model: (Constant), Chave *et al*., (2014), Djomo *et al*., (2010)

The other tables indicates Chave *et al*., (2014), Chave *et al*., (2005) and Henry *et al*, (2010) are not suitable although, they all have R^2 to be one (1) but they are not statistically significant.

COCOA PLANTATION PHYSIOGNOMY

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000[a]	1.000	1.000	1.0262407658

a. Predictors: (Constant), FELDPAUSCH, CHAVE2005, DJOMO

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2418365234.882	3	806121744.961	765424062.396	.000[b]
	Residual	36.861	35	1.053		
	Total	2418365271.743	38			

a. Dependent Variable: HENRY

b. Predictors: (Constant), FELDPAUSCH, CHAVE2005, DJOMO

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.089	.175		.506	.616
	CHAVE2005	.281	.000	.983	9875.974	.000
	DJOMO	-.119	.002	-.017	-77.633	.000
	FELDPAUSCH	.212	.002	.035	116.377	.000

a. Dependent Variable: HENRY

((F (3, 35) = 765424062.4), $p<0.05$, $R=1.000^3$, $R^2=1.000$)

Excluded Variables[a]						
Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	CHAVE2014	-.366[b]	-3.774	.001	-.543	3.367E-008

a. Dependent Variable: HENRY

b. Predictors in the Model: (Constant), FELDPAUSCH, CHAVE2005, DJOMO

The summary of analysis in the tables above suggest that CHAVE2005, DJOMO AND FELDPAUSCH jointly predict HENRY ((F (3, 35) = 765424062.4), $p<0.05$, $R=1.000^3$, $R^2=1.000$). Further investigation from the table indicates that 100% of variation is explained by the independents variables (DJOMO, CHAVE2005 AND FELDPAUSCH). From the coefficient table CHAVE2005 ($\beta= .281$, $t=9875.974$, $p<0.05$), DJOMO ($\beta= -.119$, $t=-77.633$, $p>0.05$), FELDPAUSCH ($\beta= .212$, t=116.377, p<0.05). CHAVE2005, FELDPAUSCH and DJOMO independently predict HENRY. CHAVE2014 is excluded because it is a different significant level.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000[a]	1.000	1.000	3.6473456082

a. Predictors: (Constant), HENRY, DJOMO, FELDPAUSCH

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	29491329868.618	3	9830443289.539	738957171.388	.000[b]
	Residual	465.610	35	13.303		
	Total	29491330334.228	38			

a. Dependent Variable: CHAVE2005

b. Predictors: (Constant), HENRY, DJOMO, FELDPAUSCH

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.315	.623		-.506	.616
	DJOMO	.424	.006	.018	77.085	.000

	FELDPAUSCH	-.752	.007	-.036	-115.092	.000
	HENRY	3.554	.000	1.018	9875.974	.000

a. Dependent Variable: CHAVE2005

((F (3, 35) =738957171.388), $p<0.05$, R=1.000, R^2=1.000)

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	CHAVE2014	.381[b]	8.489	.000	.824	7.402E-008

a. Dependent Variable: CHAVE2005

b. Predictors in the Model: (Constant), HENRY, DJOMO, FELDPAUSCH

The summary of analysis in the table above suggests that FELDPAUSCH, DJOMO AND HENRY jointly predict CHAVE2005 ((F (3, 35) =738957171.4), $p<0.05$, R=1.000, R^2=1.000). Further investigation from the table indicates that 100% of variation is explained by the independents variables (DJOMO, FELDPAUSCH AND HENRY). From the coefficient table FELDPAUSCH (β= -.752, t=-115.092, $p<0.05$), DJOMO (β= .424, t=77.085, $p<0.05$), HENRY (β= 3.554, t=9875.974, $p<0.05$). FELDPAUSCH, HENRY and DJOMO independently predict CHAVE2005. CHAVE2014 is excluded variables.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.996[a]	.991	.991	111.2355864975

a. Predictors: (Constant), CHAVE2005, FELDPAUSCH

MULTIPLE LINEAR REGRESSION						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	51321223.647	2	25660611.824	2073.860	.000[b]
	Residual	445440.805	36	12373.356		
	Total	51766664.452	38			

a. Dependent Variable: DJOMO

b. Predictors: (Constant), CHAVE2005, FELDPAUSCH

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	22.295	18.639		1.196	.239
	FELDPAUSCH	1.171	.029	1.327	40.959	.000
	CHAVE2005	-.017	.001	-.397	-12.266	.000

a. Dependent Variable: DJOMO

(($F (2, 36) = 2073.860$), $p<0.05$, $R=.996^3$, $R^2=.991$)

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	CHAVE2014	-184.343[b]	-13.663	.000	-.918	2.132E-007
	HENRY	-56.927[b]	-77.633	.000	-.997	2.640E-006

a. Dependent Variable: DJOMO

b. Predictors in the Model: (Constant), CHAVE2005, FELDPAUSCH

The summary of analysis in the table above suggests that FELDPAUSCH AND HENRY jointly predict DJOMO ((F (2, 36) =2073.860), $p<0.05$, R=.996[3], R^2=.991). Further investigation from the table indicates that 99.10% of variation is explained by the independents variables (FELDPAUSCH AND HENRY). From the coefficient table FELDPAUSCH (β= 1.171, t=40.959, $p<0.05$) and HENRY (β= -.017, t=-12.266, $p<0.05$). FELDPAUSCH and HENRY independently predict DJOMO. CHAVE2005 and CHAVE2014 are excluded variables.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000[a]	1.000	1.000	4.9082180872

a. Predictors: (Constant), DJOMO, CHAVE2005, FELDPAUSCH

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25044060376.039	3	8348020125.346	346525967.755	.000[b]
	Residual	843.171	35	24.091		
	Total	25044061219.210	38			

a. Dependent Variable: CHAVE2014

b. Predictors: (Constant), DJOMO, CHAVE2005, FELDPAUSCH

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.276	.839		-.329	.744
	FELDPAUSCH	.270	.009	.014	31.007	.000
	CHAVE2005	.913	.000	.991	6704.073	.000
	DJOMO	-.100	.007	-.005	-13.663	.000

a. Dependent Variable: CHAVE2014

((F (3, 35) =346525967.8), p<0.05, R=1.000[3], R^2=1.000)

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	HENRY	-.808[b]	-3.774	.001	-.543	1.524E-008

a. Dependent Variable: CHAVE2014

b. Predictors in the Model: (Constant), DJOMO, CHAVE2005, FELDPAUSCH

The summary of analysis in the table above suggests that FELDPAUSCH, DJOMO AND CHAVE2005 jointly predict CHAVE2014 ((F (3, 35) =346525967.8), p<0.05, R=1.000[3], R^2=1,000). Further investigation from the table indicates that 100% of variation is explained by the independents variables (DJOMO, FELDPAUSCH AND CHAVE2005). From the coefficient table FELDPAUSCH (β= .270, t=31.007, p<0.05), DJOMO (β= -.100, t=-13.663 p<0.05), CHAVE2005 (β= .913, t=6704.073, p<0.05). FELDPAUSCH, CHAVE2005 and DJOMO independently predict CHAVE2014. HENRY is the excluded variable.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.998[a]	.995	.995	93.6089249845

a. Predictors: (Constant), CHAVE2014, DJOMO

MULTIPLE LINEAR REGRESSION

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	66157726.220	2	33078863.110	3774.992	.000[b]
	Residual	315454.710	36	8762.631		
	Total	66473180.931	38			

a. Dependent Variable: FELDPAUSCH

b. Predictors: (Constant), CHAVE2014, DJOMO

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-15.210	15.792		-.963	.342
	DJOMO	.834	.020	.736	40.852	.000
	CHAVE2014	.016	.001	.313	17.381	.000

a. Dependent Variable: FELDPAUSCH

(($F(2, 36) = 3774.992$), $P<0.05$, $R=.998^3$, $R^2=.995$)

Excluded Variables[a]						
Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	HENRY	45.361[b]	32.231	.000	.984	2.231E-006
	CHAVE2005	-68.803[b]	-30.868	.000	-.982	9.670E-007
a. Dependent Variable: FELDPAUSCH						
b. Predictors in the Model: (Constant), CHAVE2014, DJOMO						

The summary of analysis in the table above suggests that DJOMO AND CHAVE2014 jointly predict FELDPAUSCH ((F (2, 36) =3774.992), P<0.05, R=.998[3], R^2=.995). Further investigation from the table indicates that 99.50% of variation is explained by the independents variables (DJOMO AND CHAVE2014). From the coefficient table DJOMO (β= .834, t=40.852, P<0.05), CHAVE2014 (β= .016, t=17.381, P<0.05). DJOMO and CHAVE2014 independently predict FELDPAUSCH. CHAVE2005 and DJOMO are excluded variables.

HENRY, CHAVE2005 and CHAVE2014 are good. This is because, HENRY, CHAVE2005 AND CHAVE2014 have R^2 to be one and are statistically significant.