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RESEARCH ARTICLE

FLORISTIC BIODIVERSITY AND STEM VOLUME OF KAMBUI FOREST RESERVE, KENEMA DISTRICT, SIERRA LEONE.

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Abstract

Information on floristic biodiversity and stem volume is necessary for the sustainable management of forests in Sierra Leone for the current and future generation. The aim of this paper was to investigate the flora biodiversity and stem volume of Kambui forest reserve. Random sampling quadrat methods of vegetation analysis were used to determine the flora biodiversity and stem volume. Ten sample quadrats (10m ×10m) with a distance of at least 400m away from each other were demarcated. All trees species found in the quadrats were recorded in the local and scientific name. A total of 36 species from 22 families with 122 individual's trees were recorded. The species Importance Value Index [IVI], Shannon Weiner Index, Species Richness, Simpson Diversity Index, Species Evenness, Species Dominance, Relative Frequency and Relative Density were computed to determine the floral diversity and richness. Diameter at breast height (Dbh) and total height of trees were the parameters used to estimate the stem volume. The total Shannon Weiner index for the ten quadrats was 3.241, species evenness was 0.90 while the Simpson diversity was 0.05. The regression correlation between Dbh and height was R^2 0.6344. *Parinari excelsa* had the highest average Dbh (80.13cm) and height of 47m. The total stem volume was (391.78m³). *Paracrolobium coeruleum*, *Daniella thurifera* and *Parinari excelsa* recorded the highest (IVI). The study revealed that the flora biodiversity of Kambui forest reserve is low as compared to other regions in the country. Biotic pressure among other factors contributed to the decline of the flora biodiversity but the stem volume potential was great. It is recommended that if sound management strategies are put in place, Kambui forest has the potential to increase its biodiversity and stem volume while at the same time meeting the needs of the locals.

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Introduction:-

Sierra Leone used to represent one of the most unique and important ecosystems in West Africa and the world at large. Located within the Upper Guinea rainforest region, Sierra Leone has previously had a variety of distinct

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ecosystems that provided critical habitat for some of the world's rarest species and hosts abundant richness of biodiversity, and biological uniqueness in terms of endemism and number of rare and threatened species (US, AID 2015; World Bank 2009). Sierra Leone's biodiversity has gone through a period of slow, but steady decline since the colonial era (NBSAP, 2017). The forest estate in Sierra Leone comprises of the main forest reserves (the Gola, Kambui, Tama-Tonkoli, Western Area); the protected strip forests belonging to chiefdoms; the game reserves Qutamba-Kilimi, Mamunta-Myosa (FAO, 1996). It has been estimated that 70 percent of the country was at one time forested but the current distribution of forests hardly conveys that, with just under 5 percent of the country under mature forests (NBSAP, 2017). Unfortunately, the rich floristic biodiversity has been put to a halt as result of civil war, biotic activities and the forest protection policy lapse. Furthermore, human impact on the vegetation has been the most severe, largely due to logging and slash-and-burn agriculture (US, AID, 2007; BSAP, 2005). Tropical forests are the richest biological communities on earth and these forests have been recognized to harbor a significant proportion of global biodiversity (Myers et al 2000; Baraloto et al 2013). These forests provide many ecosystem services such as species conservation, prevention of soil erosion, and preservation of habitat for plants and animals (Armenteras et al 2009) but the current status of biological diversity is diminishing rapidly and the capacities of ecological systems to function properly are being reduced (World Bank, 2009). The massive destruction of tropical forests worldwide also comes at a time when our knowledge of the structure and functional dynamics and even taxonomy of many tropical forests is still rudimentary (Parthasarathy and Sethi, 1997). Annual changes in floristic biodiversity and stem volumes are possible event in the tropical forests of Sierra Leone due to deforestation and other drivers of environmental degradation. Understanding the floral biodiversity of Kambui forest is important for its management and conservation for present and future generations.

Biodiversity is considered by many as the resource upon which families, nations and future generations depend for food, medicines, energy and other basic requirements. Biodiversity hinges upon the survival of people and communities. There are a host of reasons why biodiversity must be conserved, apart from the inherent moral and aesthetic values (NBSAP, 2017). Despite its importance, our actions are eroding this resource at a perilous rate. Several species have been lost largely due to various human activities including deforestation, wetland destruction, land degradation, over-grazing, and over-exploitation of biological resources, wild bushfires, urbanization, pollution, mining and other inappropriate human activities such as the slash and burn agriculture (BSAP, 2005). When the floristic biodiversity of a forest is being degraded its stem volume strength is affected because the volume is increased with the number of trees in a stand as well as the diameter at breast height of trees. In recent times, scientific documentation of biodiversity has assumed immediate research priority (Singh, 2012) because biodiversity maintenance is one of the major goals to attain forest sustainability while assessment of forest community composition and structure is very helpful in understanding the status of tree population, regeneration, and diversity for conservation purposes (Osorio et al 2009; Mishra et al., 2013). In the last few decades, the world has realized that the conservation and sustainable use of biodiversity are the principal pillars for sustainable development. Several natural scientists such as (Huston, 1994; Whitmore, 1998; Richards, 1963; Cannon et al., 1998; Longman and Jenik, 1987; Mabberley, 1983; Hall and Swaine, 1976; Sutton et al., 1983) have conducted studies on floristic biodiversity via species diversity in different parts of the continent. They believed that the diversity of trees is fundamental to the total forest biodiversity because trees provide resources and habitats for almost all other species. The population densities of tree species in tropical forests have intrigued ecologists such as (Bates, 1864; Wallace, 1878; Richards, 1952; Pitman et al., 1999; Hubbel, 1979) to conduct series of research in this field few decades back. In the millennia, the trend of research work in biodiversity has even increased double fold by scientist such as (Adekunle 2006; Yang et al., 2008; Jim and Liu, 2001; Jurgens et al., 2012; Feret and Asner 2014; Aladesami, 2017; Bunyavejchewin et al., 2003) have all carried out detail research in this field. Scientific and anecdotal evidence show that the world is losing its resilience against environmental stochasticity because of the disturbing rate of depletion of biodiversity, among other factors, leading to hunger, desertification, disease and climate change etc (NBSAP, 2017).

The diversity of tree species is a fundamental component of total biodiversity in many ecosystems because trees are ecosystem engineers that provide resources and habitats for almost all other forest organisms (Huston 1994). Trees, an important component of vegetation, must, therefore, be constantly monitored and managed in order to direct successional processes towards maintaining species and habitat diversity (Turner 1987; Attua and Pabi, 2013) and they form the major structural and functional basis of tropical forest ecosystems and can serve as robust indicators of changes and stressors at the landscape scale (Aigbe et al., 2015). Furthermore, tree species diversity is an important aspect of forest ecosystem diversity (Rennolls and Laumonier 2000; Tchouto et al 2006) and is also fundamental to tropical forest biodiversity (Evariste et al 2010). As tree species diversity varies significantly from location to

location because of variations in biogeography habitat and disturbance, (Whitmore, 1998), is essential for inventories to be conducted in all forest types to make available quantitative data on the structure and composition of tree species. Information on tropical plant species is needed because of its potential usefulness in understanding the relative extent of plant biodiversity across the tropics and its implication for conservation and management (Kadavul and Parthasarathy, 1999). It is generally recognized that species richness is positively associated with species abundance (Denslow, 1995; Condit et al., 1998; Hayek and Buzas, 1997; Preston, 1962) while environmental heterogeneity have strong effects on species diversity (Waide et al., 1999; Huston, 1999, 1994, 1980; Hubbel, 1997, 1998; Rosenzweig, 1995; Whitmore, 1998).

The volume of timber is essential information in guiding rational and sustainable utilization of available forest resources. Thus it is very important to quantify it as precisely as possible (Soares et al, 2011). Financial exploitation of forests composes an important part of man activity and volume is the most widely used measure of wood quantity and it can be estimated from empirical relationships between certain tree-bole dimensions and the tree volume (Diamantopoulou, 2006). Moores et al., (1996) affirmed that an estimate of the value and possible uses of timber is an important part of the broader information required to sustain ecosystems. Up-to-date information on forest resources and monitoring ongoing spatial processes in the forested landscape are of great importance to the successful and sustainable management of forest resources (Mohammadi et al., 2010).

It is very evident that a lot of work has been carried out on flora biodiversity, but very few researchers have considered working on flora biodiversity along its stem volume especially in Sierra Leone. Literature on past and current vegetation inventory on Kambui forest is rare if not unavailable for the past decades. Unfortunately, Sierra Leone as a country has not carried out a detail forest inventory survey on flora biodiversity and stem volume since 1967 (Savil and Fox, 1967). Within the past five decades a lot of trees have been felled and the environment has seen aggressive urbanization thrust, as a result of population increase and civil war. As a result of this gap in flora biodiversity and stem volume information in Sierra Leone and Kambui hill in particular, this research is set to provide this basic information and to close the huge knowledge gap that has existed for the past decades. This kind of information is useful for tree diversity management and for biodiversity recovery planning.

Materials and Methods:-

Description of study area:-

The Kambui Hills Forest Reserve is found in the Eastern part of Sierra Leone, about 300 km South-East of Freetown (NBSAP 2017). The forest is located 10 km away from the third city (Kenema) with terrain consisting of steep slopes that reach an altitude of between 100- 645m. Its population, according to the 2015 census is 609,891, thousand people (SSL, 2015). The two sections of the reserve are Kambui North 20,348 ha and Kambui South 880ha. The climate is seasonal with six month raining season (May to October) and six month dry season November to April. The weather is characterized by high temperatures with an average monthly temperature of between 26 –28 °C from June to October with a maximum temperature of 32°C (GOSL and UNDP, 2007). The vegetation of the reserve is classified as ever-green with six month of continuous rain fall. Inside the reserve the vegetation is closed consisting of three vegetation types: Albert logged forest (91%), farm bush (7.5%) and vine forest (0.7%). The Kambui hill forest serve as protection for more than 12 catchment and 8 of these catchment currently supply water by gravity to the Kenema City and its environment (Conteh, 2013).

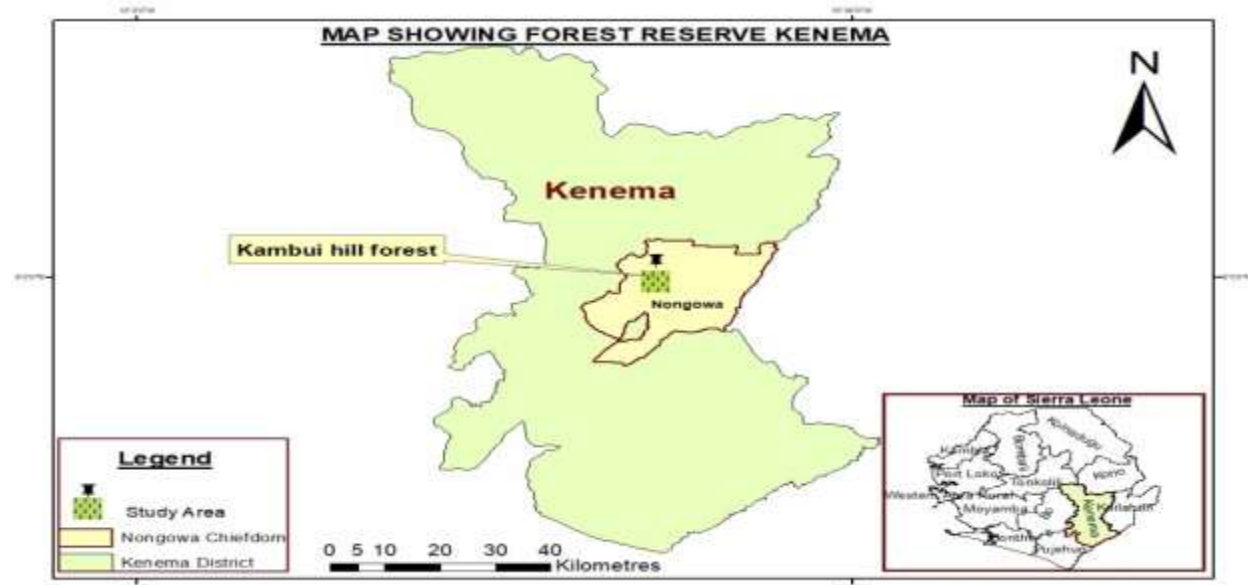


Figure 1:-Map of Kambui Forest Reserve Kenema District

Sampling methods:-

This study was carried out from June to August 2017. The random sampling quadrats methods were used to determine the flora biodiversity and stem volume. Ten sample quadrats (10m×10m) with a distance of at least 400m away from each sample quadrat were demarcated in different locations of the forest. All trees species found in the sample quadrats were recorded either in the local or scientific name and a proper diversity classification was done later. In each sampled quadrats, all trees with a Diameter at breast height (Dbh at 1.3m) ≥ 10 cm were enumerated and tagged using oil paint. The Diameter at breast height was measured using the Dbh tape while the height (m) was measured using the Haga Altimeter.

Data analysis:-

Importance Value Index (IVI):-

The Importance Value Index (IVI) was determine using the (Kent and Coker (1992), Pielon (1975), Phillip (1983, Curtis, 1950; Mishra 2013; McIntosh 1950 and Michael (1990) methods. The percentage value of the relative frequency, relative density and relative dominance are summed up together and this value is designated as (IVI) of the species.

$$\text{Density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrats studied}}$$

$$\text{Relative Density} = \frac{\text{Density of a species}}{\text{Density of all the species}} \times 100$$

$$\text{Frequency \%} = \frac{\text{Total number of quadrat of occurrence of species}}{\text{Total number of quadrats studied}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Frequency of all the species}} \times 100$$

$$\text{Dominance} = \frac{\text{Total number of individual of the species}}{\text{Total number of quadrats in which species occur}}$$

$$\text{Relative dominance} = \frac{\text{Basal area of a Species}}{\text{Basal area of all species}} \times 100$$

Shannon Weiner Diversity Index (H):-

Shannon-Wiener diversity index (Shannon and Wiener, 1963, Kent and Coker 1992 and Gaines *et al.*, 1999) was calculated from the IVI values using the formula:

$$\text{SHDI} = - \sum_{i=1}^S (P_i \times \ln P_i)$$

Where:

H^1 = is Shannon-Wiener Index of diversity, P^i = the proportion of individual of a species, S = number of species in the community, \sum = summation symbol, \ln = Natural logarithm to the base e

The Simpson's Diversity Index (D):-

Simpson diversity was calculated by methods of (Mishra, 2013, Simpson, 1949 and Magurran 1988).

$$SIDI = 1 - \sum_{i=1}^m P_i^2$$

Where:

D is the dominance of the index, $P_i =$ is the proportion of i^{th} species, $S =$ is the number of individuals of all the species.

Evenness:-

The distribution individual plant species in a given area is called evenness. Species richness and evenness are two independent plant biological community variables that form the diversity of a forest (HEIP, 1974 and Peet 1974).

$$J' = \frac{H'}{\text{Log}(S)}$$

Where:

H' is the Shannon-Wiener diversity index S is the total number of species.

Volume:-

The volume of trees (m^3) per/ha were estimated as per (Philip, 1983, Hamilton 1983) fomular.

$$V = \frac{\text{TBA} \times \text{Ht}}{3} \quad \text{Where:}$$

Tree volume (m^3) TBA = Tree Basal Area (m^2) Ht= Tree Height (m)

Results:-

The total number of trees species recorded from the ten sample quadrats were 36 belonging to 22 families with 122 individual trees species. Quadrats 1, 4, and 7 accounted for (34.4%) of the total number of individual trees enumerated. Subsequently, quadrats 3, 4 and 9 were the only quadrats with trees recording 100cm (4.1%) and above Dbh. *Parinari excelsa* recorded the highest Dbh (122cm) and a height of 49m. Three species; *Paracrolobium coeruleum*, *Daniella thurifera* and *Parinari excelsa* accounted for (14.8%) for the total individual species. Quadrats 4, 6 and 7 recorded more families than others. Cesalpiniaceae is recorded as the most species rich family accounting for (36.4%) of the total plant families, followed by Rosaceae and Sterculiaceae each accounting for 13.6% of the species respectively. More than (60%) of the stems Dbh were ≤ 30 cm. The total stem volume of the 36 plant species was (391.78m^3 Table 1). *Parinari excelsa*, (49.67m^3) *Parkia bicolor* (32.37m^3), and *Chlorophora regia* (28.53m^3), recorded the highest volume while the mean volume was ($10.9\text{m}^3/\text{ha}$, Table 2).

The mean Dbh of all trees was (27.8cm) while the mean density was (33.8 d/ha). *Parinari excelsa* recorded the highest basal cover of (4.6%, Table 2). *Parinari excelsa*, *Daniella thurifera* and *Paracrolobium coeruleum* recorded equal highest relative density of (7.3%) while *Parinari excelsa* recorded the highest relative dominance of (37.3%) followed by *Piptadeniastrum africana* (7.3%, Table 2). The mean height of trees was 13.7m while the mean Girth/basal area was estimated to be ($1.14\text{m}^2/\text{ha}$). The IVI was high for *Parinari excelsa*, (50.4%) *Daniella thurifera* (19.0%), *Paracrolobium coeruleum* (18.6%). The total Shannon index was 3.241, Species evenness (0.90) and the total Simpson diversity index was 0.05. *Paracrolobium coeruleum* recorded higher percent frequency of (70).

Table 1:- Scientific, local and family names of trees species at Kambui forest reserve

Scientific Names of species	Local Names	Family Names	Trees No	Ave girth	Ave Dbh	Ave hts	Qdts Occ	Vol M3
<i>Parinari excelsa</i>	Ndawei	Rosaceae	9	251,61	80,13	47	5	49,67
<i>Parkia bicolor</i>	Gumui	Mimosaceae	2	202,84	64,6	38	2	32,37
<i>Chlorophora regia</i>	Semei	Moraceae	3	170,06	54,16	40	3	28,57
<i>Piptadeniastrum africanum</i>	Mbelei	Rosaceae	5	150,22	47,84	29	3	18,3
<i>Morelia senegalensis</i>	Kafii	Rubiaceae	4	123,31	39,27	42	2	21,75
<i>Dialium guineensis</i>	Mambui	Cesalpiniaceae	2	121,68	38,75	39	2	19,93
<i>Ochthocosmus africanus</i>	Twanyeh	Ixonanthaceae	3	113,35	36,1	39	2	18,57

<i>Cryptosepalum tetraphyllum</i>	Kpavii	Cesalpiniaceae	1	110,21	35,1	37	1	17,13
<i>Daniella thurifera</i>	Gbessei	Cesalpiniaceae	9	109,27	34,8	39	4	17,9
<i>Trichoscypha arborea</i>	Kpomaluwai	Anacardiaceae	1	105,19	33,5	41	1	18,11
<i>Nauclea diderrichii</i>	Bundui	Rhamnaceae	5	100,92	32,14	22	3	9,32
<i>Brachestegia leonensis</i>	Gbojie	Cesalpiniaceae	4	99,85	31,8	40	4	16,78
<i>Blighia sapida</i>	Yokomei	Sapindaceae	3	94,61	30,13	41	1	16,29
<i>Cassia seiberiana</i>	Gbangbei	Cesalpiniaceae	2	87,92	28	24	1	8,86
<i>Detarium senegalensis</i>	kpuyai	Cesalpiniaceae	2	85,41	27,2	30	2	10,76
<i>Phyllanthus discoides</i>	Tijoi	Euphorbiaceae	1	83,84	26,7	18	1	6,34
<i>Heritiera utilis</i>	Yawei	Sterculaceae	7	82,39	26,24	25	5	8,65
<i>Octoknema borealis</i>	Kotuwei	Octoknemataceae	6	75,08	23,91	17	5	5,36
<i>Paracrolobium coeruleum</i>	Telii	Cesalpiniaceae	9	74,17	23,62	24	7	7,48
<i>Entandophragma angolense</i>	Njelei	Meliaceae	2	73,16	23,3	16	2	4,92
<i>Albizia zygia</i>	Kpakpei	Mimosaceae	1	68,14	21,7	19	1	5,44
<i>Funtumia africana</i>	Boboi	Apocynaceae	6	65,72	20,93	31	3	8,56
<i>Cola laterita</i>	Bunei	Sterculaceae	3	65,41	20,83	18	2	4,94
<i>Lophira alata</i>	Hendui	Sterculaceae	2	58,72	18,7	15	2	3,7
<i>Fagara macrophylla</i>	Sowuli	Rutaceae	4	58,4	18,6	15	3	3,68
<i>Pterocarpus Santalinoideis</i>	Gbatui	Papilionaceae	1	58,09	18,5	13	1	3,17
<i>Strombosia glaucescens</i>	Kovui	Olacaceae	3	56,21	17,9	13	3	3,07
<i>Diospyros gabunensis</i>	Ndokuwuli	Ebenaceae	2	52,12	16,6	13	2	2,85
<i>Gilbertioden drumaylmeri</i>	Gugui	Caesalpiniaceae	1	50,87	16,2	19	1	4,06
<i>Hanoa klaneana</i>	Gbovui	Simaroubaceae	6	49,02	15,61	13	3	2,68
<i>Klainedoxa gabonensis</i>	Gbewei	Irvingiaceae	2	46,16	14,7	13	1	2,52
<i>Guarea Leonensis</i>	Jaywei	Meliaceae	1	45,22	14,4	11	1	2,09
<i>Alablackia floribunda</i>	solehwui	Guttiferaceae	1	40,82	13	10	1	1,71
<i>Musanga cecropides</i>	Ngovui	Moraceae	3	38,18	12,16	13	3	2,08
<i>Smeathmania laevigata</i>	Ndovotei	Passifloraceae	5	36,11	11,5	18	3	2,73
<i>Pentaclethra macrophylla</i>	Fawei	Rosaceae	1	34,54	11	10	1	1,45
Total 36 species			122				10	391,78

Ave=Average, Dbh=Diameter at breast height, Qdts=Quadrat, Vol=Volume, Hts=Height, Occ=Occurrence and No=Number.

Table 2:-Trees Density, Frequency, Abundance Importance Value Index, Shannon, Simpson etc.

Scientific names	Trees No.	Ave Girth	Ave Dbh	Qdts occu	Ab un	D/ha	F %	BC	RD	RF	RD O	IVI	SH DI	SDI
<i>Parinari excelsa</i>	9	251,6	80,13	5	1,8	90	50	4,601	7,377	5,747	37,316	50,440	-0,300	0,028
<i>Parkia bicolor</i>	2	202,8	64,60	2	1,0	20	20	0,665	1,639	2,299	5,390	9,328	-0,108	0,001

<i>Chlorophora regia</i>	3	170,1	54,1 6	3	1,0	30	3 0	0,7 01	2,4 59	3,4 48	5,6 82	11, 590	- 0,1 26	0,0 01
<i>Piptadeniastrum africanum</i>	5	150,2	47,8 4	3	1,7	50	3 0	0,9 11	4,0 98	3,4 48	7,3 89	14, 936	- 0,1 49	0,0 02
<i>Morelia senegalensis</i>	4	123,3	39,2 7	2	2,0	40	2 0	0,4 91	3,2 79	2,2 99	3,9 83	9,5 61	- 0,1 10	0,0 01
<i>Dialium guineensis</i>	2	121,7	38,7 5	2	1,0	20	2 0	0,2 39	1,6 39	2,2 99	1,9 39	5,8 77	- 0,0 77	0,0 00
<i>Ochthocosmus africanus</i>	3	113,4	36,1 0	2	1,5	30	2 0	0,3 11	2,4 59	2,2 99	2,5 25	7,2 82	- 0,0 90	0,0 01
<i>Cryptosepalum tetraphyllum</i>	1	110,2	35,1 0	1	1,0	10	1 0	0,0 98	0,8 20	1,1 49	0,7 96	2,7 65	- 0,0 43	0,0 00
<i>Daniella thurifera</i>	9	109,3	34,8 0	4	2,3	90	4 0	0,8 68	7,3 77	4,5 98	7,0 38	19, 013	- 0,1 75	0,0 04
<i>Trichoscypha arborea</i>	1	105,2	33,5 0	1	1,0	10	1 0	0,0 89	0,8 20	1,1 49	0,7 25	2,6 94	- 0,0 42	0,0 00
<i>Nauclea diderrichii</i>	5	100,9	32,1 4	3	1,7	50	3 0	0,4 11	4,0 98	3,4 48	3,3 35	10, 882	- 0,1 20	0,0 01
<i>Brachestegia leonensis</i>	4	99,9	31,8 0	4	1,0	40	4 0	0,3 22	3,2 79	4,5 98	2,6 12	10, 488	- 0,1 17	0,0 01
<i>Blighia sapida</i>	3	94,6	30,1 3	1	3,0	30	1 0	0,2 17	2,4 59	1,1 49	1,7 59	5,3 67	- 0,0 72	0,0 00
<i>Cassia seiberiana</i>	2	87,9	28,0 0	1	2,0	20	1 0	0,1 25	1,6 39	1,1 49	1,0 13	3,8 01	- 0,0 55	0,0 00
<i>Detarium senegalensis</i>	2	85,4	27,2 0	2	1,0	20	2 0	0,1 18	1,6 39	2,2 99	0,9 55	4,8 94	- 0,0 67	0,0 00
<i>Phyllanthus discoideus</i>	1	83,8	26,7 0	1	1,0	10	1 0	0,0 57	0,8 20	1,1 49	0,4 60	2,4 29	- 0,0 39	0,0 00
<i>Heritiera utilis</i>	7	82,4	26,2 4	5	1,4	70	5 0	0,3 84	5,7 38	5,7 47	3,1 12	14, 597	- 0,1 47	0,0 02
<i>Octoknema borealis</i>	6	75,1	23,9 1	5	1,2	60	5 0	0,2 73	4,9 18	5,7 47	2,2 15	12, 880	- 0,1 35	0,0 02
<i>Paracrolobium coeruleum</i>	9	74,2	23,6 2	7	1,3	90	7 0	0,4 00	7,3 77	8,0 46	3,2 42	18, 665	- 0,1 73	0,0 04
<i>Entandophragma</i>	2	73,2	23,3	2	1,0	20	2	0,0	1,6	2,2	0,7	4,6	-	0,0

<i>angolense</i>			0				0	86	39	99	01	39	0,0 64	00
<i>Albizia zygia</i>	1	68,1	21,7 0	1	1,0	10	1 0	0,0 37	0,8 20	1,1 49	0,3 04	2,2 73	- 0,0 37	0,0 00
<i>Funtumi africana</i>	6	65,7	20,9 3	3	2,0	60	3 0	0,2 09	4,9 18	3,4 48	1,6 97	10, 064	- 0,1 14	0,0 01
<i>Cola laterita</i>	3	65,4	20,8 3	2	1,5	30	2 0	0,1 04	2,4 59	2,2 99	0,8 41	5,5 98	- 0,0 74	0,0 00
<i>Lophira alata</i>	2	58,7	18,7 0	2	1,0	20	2 0	0,0 56	1,6 39	2,2 99	0,4 52	4,3 90	- 0,0 62	0,0 00
<i>Fagara macrophylla</i>	4	58,4	18,6 0	3	1,3	40	3 0	0,1 10	3,2 79	3,4 48	0,8 94	7,6 21	- 0,0 93	0,0 01
<i>Pterocarpus Santalinoides</i>	1	58,1	18,5 0	1	1,0	10	1 0	0,0 27	0,8 20	1,1 49	0,2 21	2,1 90	- 0,0 36	0,0 00
<i>Strombosia glaucescens</i>	3	56,2	17,9 0	3	1,0	30	3 0	0,0 77	2,4 59	3,4 48	0,6 21	6,5 28	- 0,0 83	0,0 00
<i>Diospyros gabunensis</i>	2	52,1	16,6 0	2	1,0	20	2 0	0,0 44	1,6 39	2,2 99	0,3 56	4,2 94	- 0,0 61	0,0 00
<i>Gilbertioden drumaylmeri</i>	1	50,9	16,2 0	1	1,0	10	1 0	0,0 21	0,8 20	1,1 49	0,1 69	2,1 39	- 0,0 35	0,0 00
<i>Hanoa klaineana</i>	6	49,0	15,6 1	3	2,0	60	3 0	0,1 16	4,9 18	3,4 48	0,9 44	9,3 10	- 0,1 08	0,0 01
<i>Klainedoxa gabonensis</i>	2	46,2	14,7 0	1	2,0	20	1 0	0,0 34	1,6 39	1,1 49	0,2 79	3,0 68	- 0,0 47	0,0 00
<i>Guarea Leonensis</i>	1	45,2	14,4 0	1	1,0	10	1 0	0,0 17	0,8 20	1,1 49	0,1 34	2,1 03	- 0,0 35	0,0 00
<i>Alablackia floribunda</i>	1	40,8	13,0 0	1	1,0	10	1 0	0,0 13	0,8 20	1,1 49	0,1 09	2,0 78	- 0,0 34	0,0 00
<i>Musanga cecropides</i>	3	38,2	12,1 6	3	1,0	30	3 0	0,0 35	2,4 59	3,4 48	0,2 86	6,1 94	- 0,0 80	0,0 00
<i>Smeathmania laevigata</i>	5	36,1	11,5 0	3	1,7	50	3 0	0,0 53	4,0 98	3,4 48	0,4 27	7,9 74	- 0,0 96	0,0 01
<i>Pentaclethra macrophylla</i>	1	34,5	11,0 0	1	1,0	10	1 0	0,0 10	0,8 20	1,1 49	0,0 78	2,0 47	- 0,0 34	0,0 00
36 species	122					12 20	8 7	12, 330	10 0	10 0	100	300	3,2 41	0,0 57

							0							
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Ave= Average, D/ha= Density per hectare, F%= Percent frequency, BC=Basal cover, RF=Relative frequency, IVI= Importance value index, SHDI= Shannon Weiner Index and SDI= Simpson Diversity Index

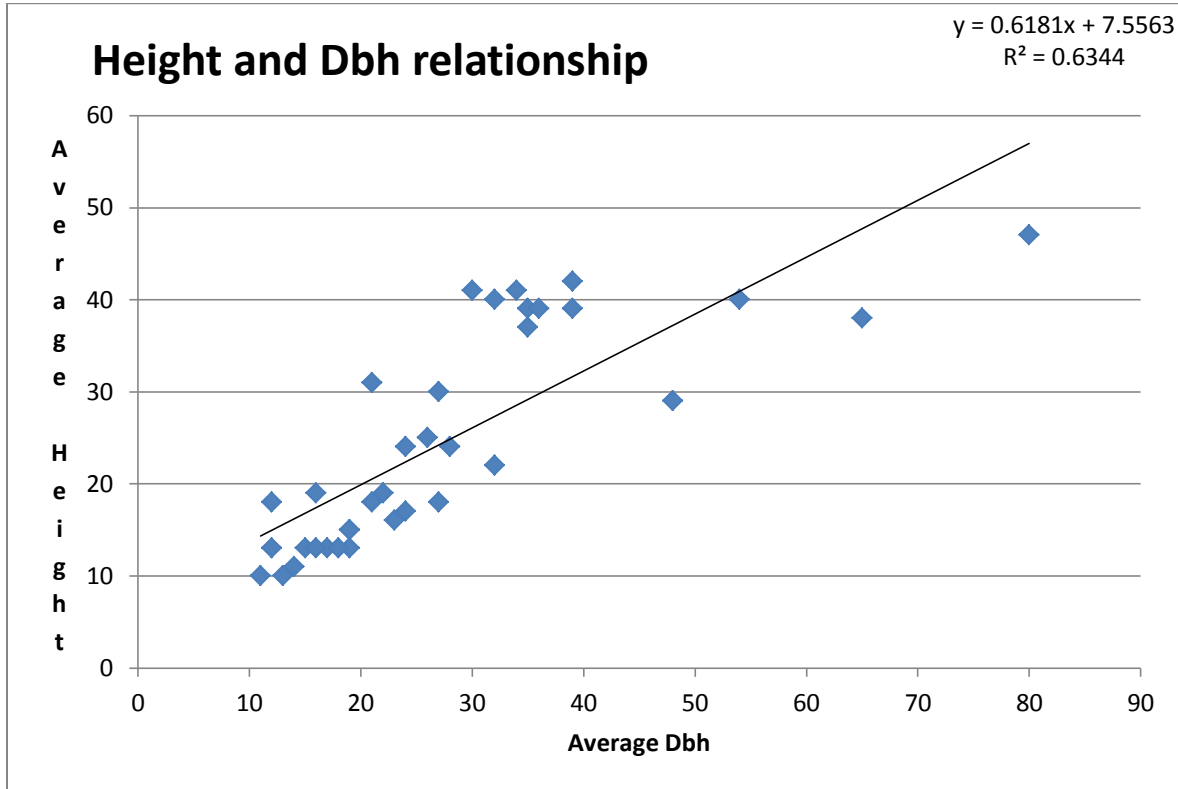


Figure 2:- Linear Relationship between Dbh and Height.

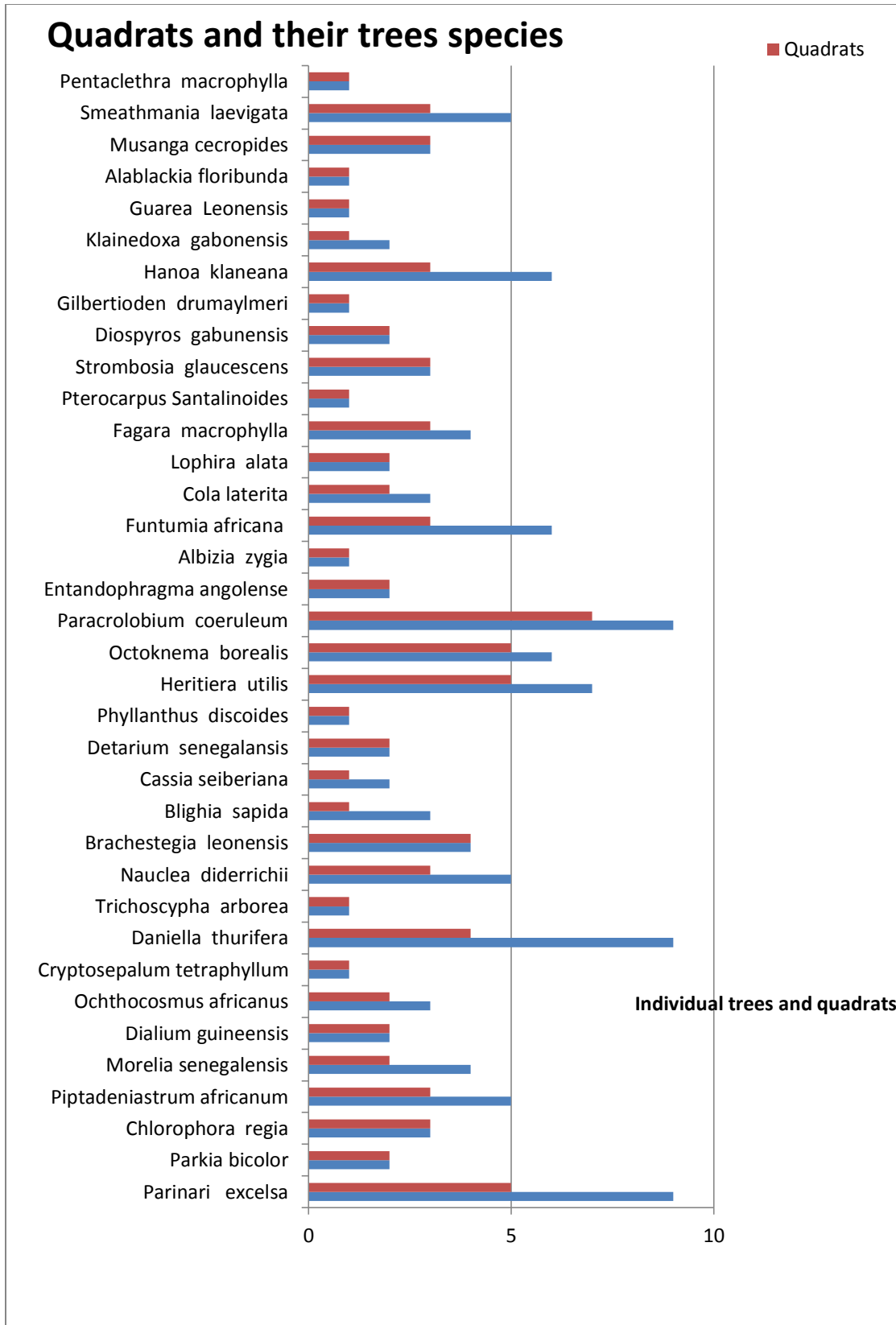


Figure 3:- Quadrats and their trees species

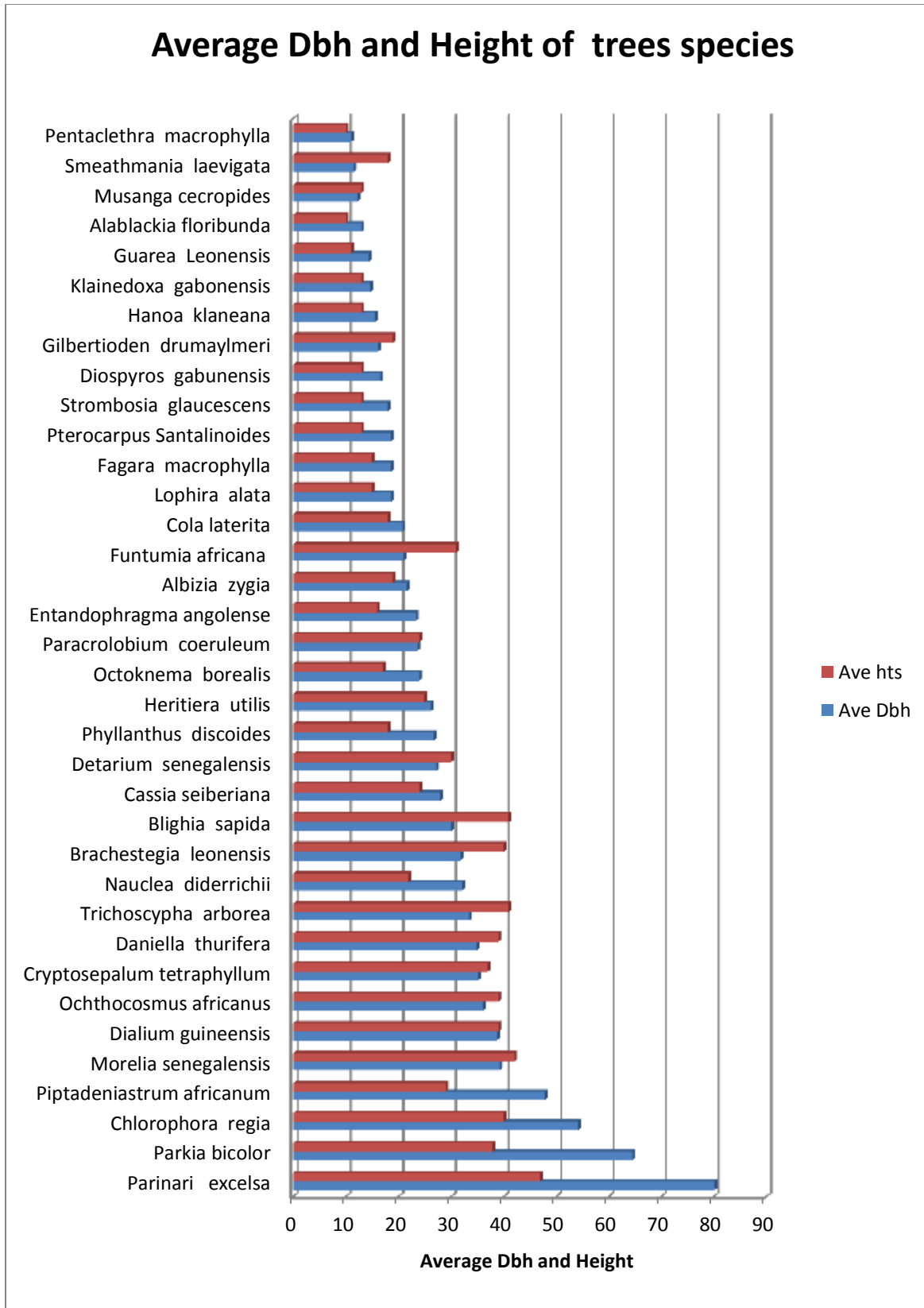


Figure 4:- Average Dbh and Height of trees species

Discussions:-

The presence of 36 trees species from 22 families with 122 individuals at Kambui forest shows a low level of flora biodiversity in the forest reserve (Table 1). The reason for this low level of biodiversity status for a reserve could be due to constant pressure from the surrounding communities for fuel wood, charcoal, poles, illegal logging, and hunting activities. Meanwhile, 36 species from 151 individual trees were reported by Fayiah and Koroma, (2015) while 132 plant families from 1200 individual trees in a 1.01ha was also reported by Kargbo (2009) in the South and Eastern part of the country respectively. Additionally, 42 species from 160 individual trees from 20 families in a 1.18ha was also reported by Fayiah and Bendu (2016) at the Kasewe forest reserve. Furthermore, Bangura (2013) reported 1150 trees/ha from 58 plant families in an area of 1.40 ha at the Singaba forest reserve in the South. The various studies indicate that, the flora richness and abundance in Kambui forest is low as compared to other regions of the country. It is strongly believed that ecological (e.g. fires) and anthropogenic (e.g. logging, extraction of forest products, shifting cultivation) disturbances are known to affect total species numbers and species composition of forests (Geist and Lambin, 2002; Pimm et al., 2001; Hall et al., 2003) and are reported to be the major causes of species loss (Sala et al., 2000). When compared with 33 trees species recorded in a 0.1ha sample plot in Tanzania (Huang et al 2003), one could clearly see the evidence of great forest disturbance and biodiversity loss across the continent. Plant families such as Cesalpiniaceae, Rosaceae and Sterculiaceae (36.4%, 13.6%, 13.6%) were found to be the most abundant family among the 22 families. These families and their species are common in most tropical rain forest as noted by Reynal-Roques (1994). On the contrary, Klop et al., (2008) found out that Gola Forest in the same Eastern region of the country is dominated by Leguminosae, with common species such as *Cynometra leonensis* and *Brachystegia leonensis*. These two findings show how unique the flora biodiversity of Sierra Leone is with each eco-system exhibiting different plant species and families. Several cause could tend to explain this variation in floral diversity; high rainfall potential, sunlight, soil type, anthropogenic actions and topography. Also, the dominance of few families is an indication of low floral diversity. The plant community of the study area is largely made up of *Parinari excelsa*, *Paracrolobium coeruleum* and *Daniella thurifera* (Fig. 3).

The Importance Values Index of species clearly displays the dominance of certain species in a given community. The total IVI value was 300 which is an acceptable figure in computing the importance value. The species with the highest IVI were *Parinari excelsa* (50.40), *Daniella thurifera* (19.01), *Paracrolobium coeruleum* (18.66) while the lowest IVI were species *Pterocarpus santalinoides* (2.07) *Pentaclethra macrophylla* (2.16), and *Alablackia fliouribunda* (2.07, Table 2). Alternately, *Guibouria copallifera*, from the Caesalpiniaceae family, *Fagarama macrophalla*, from the Rubiaceae family, and *Drypetesau brevilei* were the most dominant species recorded in Kasewe forest (Fayiah and Bendu, 2016) while *Nosogordonia papaverifera* and *Terminalia ivorensis* were dominant in Singamba forest (Bangura, 2013). The dominance of species in a certain community could be attributed to factors such as soil fertility, water availability, stress resistance ability, fire resistance ability etc. unfortunately it is apparent that most dominance species in a given community would face serious challenges if those species are of economic and indigenous importance to the surrounding communities.

The Dbh is the most important indicator of tree growth and other trees parameters such as volume. *Parinari excelsa* recorded the highest Dbh (80.13cm) followed by *Parkia bicolor* (64.6cm) *Chlorophora-regia* (54.16, Fig 4). One reason for the high Dbh recorded by this species could be due to it less value for timber and pole use. Other species of good timber grade or other important functions such as *Heritiera utilis* recorded low Dbh as a result of their exploitation rate with it current conservation status being vulnerable. Parameters such as rainfall, soil type, topography, anthropogenic activities and so forth is believed to affect the increase or decrease in trees diameter over time. Dbh size and trees total height determine the volume of the tree in a given forest and have direct link to the volume of trees. The total tree volume recorded was (391.78m³). *Parinari excelsa* and *Parkia bicolor* recorded the highest volume ha⁻¹ (49.67) and (32.37) respectively. The volume of wood is important because wood is the principal financial or economic products from trees and it contain biomass in it. Though the overall stem volume is low, however, there is a potential for volume increment if all the trees are allowed to grow with minimal disturbance. The linear correlation between height and Dbh was R², 0.6344 which simply means the relationship was satisfactory (Fig 2).

The density, abundance and distribution of individual species are the measurable indicators of plant diversity (Wattenberg and Breckle, 1995). The density of trees in any forest always show the numerical strength of a species whilst the relative density shows the numerical strength of a species in relation to the total number of individual enumerated in that forest Fayiah and Koroma, (2015). The mean tree density per ha was 33.8 trees. This is far lesser than the 378 stem ha⁻¹ with a mean basal area of 15.22m²/ha reported by Fayiah and Koroma (2015) at the Taia

riparian forest in the South. The density of trees (30 cm Girth at breast height (Gbh) and above) in tropical forests is reported to vary between 245 and 859 stems⁻¹ as per (Richard, 1996; Ashton 1964; Campbell et al., 1992). Low mean density of trees could be explained by the fact that it is dominated by only few species, families as well as the biotic pressure from surrounding communities. However, *Parinari excelsa*, *Daniella thurifera*, and *Paracrolobium coeruleum* recorded a density of 90 trees ha⁻¹ each (Table 2). When compared to other tropical forest within the West African region, Appiah, (2013) in Ghana, reported 21 mean tree per ha. In fact throughout Sierra Leone and most West African countries, the density of trees is on the decrease as a result of anthropogenic activities to support livelihood. Comparing these findings to other results from tropical forest around the world, a significant difference stands out clearly and showcased the extent of disturbance and pressure that the study area is experiencing.

Species diversity depends on the adaptation of species and increases with the stability of community (Knight, 1975) and Shannon index (H) is generally higher for tropical forest. The Shannon Weiner index was 3.241 while the Simpson diversity index was 0.05 (Table 2). This indicates that the studied area though under biotic pressure but is fairly diverse because the higher the Shannon- wiener index, the higher the diversity. The H, value for Kasewe and Singaba forest were 0.745 and 2.98 (Fayiah and Bendu, 2016; Bangura, 2013). The reason for variation in Shannon values with previous studies could be due to population of surrounding communities, soil type, anthropogenic activities, mining, rainfall intensity, charcoal and fuel wood collection and so forth. Comparatively, Aigbe et al., (2015) reported that the Shannon-Wiener diversity index (H') for Afi River Forest Reserve and Oban Forest Reserve (Nigeria) were 3.827 and 3.795 respectively. Sahoo et al., (2017) in Asia, also recorded similar Shannon and Simpson diversity index of 3.66 and 0.10 respectively in Odisha India. These values are typical for tropical forest around the world but deforestation and other man made activities are affecting the diversity of trees species in tropical forests. The species with the highest Shannon diversity index was *Parinari excelsa* (0.300). According to Orth and Colette (1996), the Shannon diversity index has strong values for species with recoveries of same importance and it takes low values, when some species have strong recoveries. Demographic changes, poverty, policy responses of countries to ecological (e.g. fires), and anthropogenic disturbances (e.g. logging, agricultural expansion) and climate change (Condit et al., 1996; Pimm et al., 2001; Geist and Lambin, 2002; Novick et al., 2003; Kolb and Diekmann, 2004; Stork, 2010) are responsible for the increase and decrease of plant species globally.

For a sustainable forest management, decision and policy makers need high quality information of available forest resources (Aertsen et al., 2010). GoSL (2007), ascertain that the lack of planned management and control in reserved forests of Sierra Leone, led to increase in illegal felling, shifting cultivation, mining, charcoal burning, frequent wild fires and land degradation with severe erosion problems. The principal threats to biodiversity loss in Sierra Leone can be attributed broadly to unsustainable land use practices, the influence of the mining industry, although additional specific and over-arching issues such as poverty, lack of human capacity, and inadequate investment laws also play a role (US, AID, 2007). One of the most serious negative impacts of deforestation on the natural vegetation is the loss of species, some of which may be unknown to science in terms of economic potential and usefulness to mankind. Though this work does not cover the entire Kambui forest, the result however, is an eye opener for the forestry division and governing authorities in Sierra Leone.

Conclusion:-

In summary, the decline in the flora biodiversity of Kambui forest reserve is as a result of its close proximity to Kenema city where 80% of the city's population directly depends on the forest for energy (fuel wood), charcoal, poles, non-wood products and timber for construction. Looking at the low flora biodiversity of the study area, the forest will not be able to recover or increase its biodiversity without the intervention of forestry division and other non-governmental organization engaged in environmental management and conservation. It is recommended that sound management strategies be put in place to increase the biodiversity and stem volume while at the same time meeting the needs of the locals. The use of an outdated and almost three decade old forestry Act of 1988 is believed to be contributing to the forest loss as the penalties and fines for culprits is relatively nothing to worry about. This result clearly demonstrate the value of conducting regular inventory research especially in developing countries not just for scientific knowledge sharing but for monitoring the rate of biodiversity loss. Furthermore, this research have provided a base line survey on the flora biodiversity and stem volume of Kambui forest for decision makers and future researchers.

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