

# **A Baseline Environmental Impact Assessment (EIA) of Proposed Site for Thermal Desorption Unit (TDU) Waste Management Project in Rivers State, Nigeria: Floristic Composition Approach**

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**Abstract:** This report describes the results of a wet and dry season ecological baseline impact assessment study based on the context of a proposed Thermal Desorption Unit (TDU) development project in Eteo Eleme, Rivers State. Thermal Desorption Unit project of the magnitude of a waste management project must always have some negative effects on the quality and quantity of the environment. Following an environment impact assessment (EIA) a series of mitigation measures must be put in place to minimize the intensity of the negative effect of the project on the environment. The paper seeks to assess through baseline data the envisaged impact of the project on the existing conditions of the biophysical environment, to appraise the possible risk to the environment and mitigation measures adopted. It uses a combination of standard procedures of integrated data sources to qualitatively and quantitatively assess the floristic profile of the project study area. The result highlights most of the biophysical impact variables that will have negative effect on the environment. However, the study site still maintains the status of abundance, richness and evenness with obvious similarity in floristic composition and forest structure to that in tropical forest elsewhere in the world. It is obvious that the Eteo vegetation system is gradually under ecological succession resulting to secondary vegetation system without proper articulation of its wealth of flora diversity, but with high flora diversity in rainy season than dry season. The useful application of phyto-sociological indices in determining the status of its vegetation complex in terms of species abundance, density, importance value index, diversity and distribution pattern is being recorded in the Table for both wet and dry seasons. The paper emphasizes the need for sound environmental commitments to the project and to appraise their implementation. A proper balance between the expected benefits from the project and cost implication can only be obtained through impact studies and careful monitoring.

**Keywords:** Species Diversity, Abundance, Importance Value Index, Density

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## **1. Introduction**

Baseline studies usually entail a collection of background information and data on the physical environment and socio-economic setting of a proposed site for development. As an inevitable factor in environmental management, it is done prior to impact assessment of the given area. It is an

environmental evaluation benchmark which aids in the assessment of impacts and / or effect of existing facilities and / or on – going operation or proposed project on the environment. It is a hazard and effect management process that provides assurance for sustainable environmental practices at any project location. It seeks to strike a balance between obtaining sufficient information to describe existing

features, their inter-relationship and overall environmental status or quality, while obtaining detailed data on the current status and trends of the vegetation to enable specific impacts be predicted [1].

A Vegetation baseline study is an aspect of Environmental Impact Assessment (EIA) for the proposed TDU project. This aims at determining the current state of the environment and assesses the likely impact of the project on the environment. Socio-ecological changes are always enshrined in every developmental activity [2]. A good monitoring and evaluation system will indicate any probable changes and results of activities, including eventual impacts and the extent of the desired results achieved and their sustainability [3, 4, 5].

Thermal desorption is a term applied to many different types of soil remediation technologies. It is an *ex-situ* means to physically separate volatile and some semi-volatile contaminants from soil, sediments, sludges, and filter cakes. It is a thermally induced physical separation process. All of these technologies consist fundamentally of a two-step process, involving the application of heat to a contaminated material, such as soil, sediment, sludge, or filter cake, to vaporize the contaminants into a gas stream, which subsequently is treated to meet regulatory requirements prior to discharge [6, 7]. Varieties of gas treatment technologies are used to collect, condense, or destroy these volatilized gases. Contaminants are vaporized from a solid matrix and are transferred into a gas stream where they can be more easily managed by treatment prior to discharge. Options used to manage or treat the contaminant-laden gas stream may consist of condensation, collection, or combustion. For the first two options, the condensed or collected contaminants usually are treated off-site at some time subsequent to heat application, while in the third option, combustion, treatment occurs on-site, immediately after the gases exit heating process [8, 9].

Thermal desorption is applicable to organic wastes and generally is not used for treating metals and other inorganics. Depending on the specific thermal desorption vendor selected, the technology heats contaminated media between 200 - 1,000°F, driving off water and volatile contaminants. Off-gases may be burned in an after burner, condensed to reduce the volume to be disposed, or captured by carbon adsorption beds. In addition to volatilizing organic contaminants contained in the waste feed, moisture is volatilized and leaves with the off-gas. As a result, the thermal desorption system also functions as a dryer. In fact, many vendors refer to the primary treatment chamber of their system as a "rotary dryer," highlighting its effect on the material, despite its principal purpose of evaporating and separating out the contaminants [8, 10].

The proposed TDU EIA project is one among the work stream in Environmental Management Improvement Program Initiative (EMIP) of Oil and Gas organisations. This is of fundamental importance for environmental management plan (EMP). The EMIP road map towards operational performance improvement requires proper EIA to be executed as a preventive measure to reduce and provide full real time transparency in the handling and management of organic and

other hydrocarbon generated waste such as drill cuttings and other toxic substances.

Consequently, this has created the need for the assessment and evaluation of the flora biodiversity of the study area as to contribute to the delivery of the EMIP mandates and objectives. On a parallel *maxim* baseline study ensures that the proposed activities of the TDU project are executed in accordance with statutory requirements. The tropical rainforest constitutes the most biologically diverse terrestrial ecosystem on earth [11]. It is the predominant natural forest in Nigeria occupying about 10% of land mass which have been extensively degraded and exist in patches. Across the world, 25 hot-spots have been identified on the basis of species endemism and degree of threat through habitat loss [12]. Forest vegetation represents an important natural resource with diverse scientific, technological, cultural and ecological values at the local, state, national and international levels of societal needs. Quite a number of endemic plant species, which might be of immense economic importance to man and new to science might abound in the study area hence the need for baseline studies prior to the execution of the project. Despite these immense economic and ecological values of forest to man, series of ecological demands by the society are causing significant and irreversible loss to this unique resource [13]. Therefore, in order to assess the levels of future impacts envisaged to emanate due to the TDU project on the ecological biota of the environment, a comprehensive baseline enumeration of flora composition of the area was designed and carried out in wet and dry season. The preparation of the EIA will also support subsequent application and acquisition for Environmental Management Plan (EMP) and Associated Environmental permits for the project.

The proposed baseline study was conducted under the context and premise of reviewing existing literature of the study area including study reports if any, determination and description of the vegetation type, structure and floristic composition of the study zones, determination of key species population and their distribution in terms of phytosociological index of abundance, and develop cost effective mitigation / ameliorative measures, monitoring plans and Environmental Management Plan that meet regulatory requirements. Thus, with the aim of providing and establishing through biological studies appropriate ecological data on the existing status of all identifiable and associated components of vegetation biota of the people and their environment, assessment of the potential positive and negative impact of the proposed project on the environment, proposing appropriate mitigation measures to minimize negative environmental impacts arising from the project and enhance positive impact on the environment, to incorporate the recommendations and fall-out of the EIA process into detailed project design and decisions and suggesting effective environmental management plan. Consequently, developing an environmental management plan (EMP) for all phases of the project development, to give confidence to the planning system by providing for public participation and for consultation processes and to help in the identification of possible alternative processes. Based on the

above objectives, provide an operation plan as a surveillance network programme to monitor performance and activities of the proposed project.

## 2. Materials and Methods

### 2.1. Geographical Description of the Study site / Area

The study site is located within Eteo Community, Eleme Local Government Area (LGA) of Rivers State, Nigeria. It is located between Lat.  $4^{\circ} 45' 10''\text{N}$  &  $4^{\circ} 45' 20''\text{N}$  and Long.  $7^{\circ} 10' 20''\text{E}$  &  $7^{\circ} 10' 30''\text{E}$ . (Figs. 1, 2). The study areas are located in the rainforest belt within the equatorial climate region, characterized by high rainfall, high relative humidity and maximum temperature. It is characterized by vegetation complex of primary and secondary structure, heterogenous in nature, with spatial (closed and sparse) and vertical distribution of trees, herbs, shrubs and climbers (lianas) belonging to different families under local environmental conditions and edaphic nature. Such dominant families of plant species include Melastomataceae, Poaceae, Euphorbiaceae, Rubiaceae, Fabaceae, Costaceae, Tiliaceae, Asteraceae, Malvaceae, Cyperaceae, Lamiaceae, Amaranthaceae, Apocynaceae, Verbenaceae, Acanthaceae, and Connaraceae. Others are Convolvulaceae, Arecaceae, Moraceae, Commelinaceae, Smilacaceae, Araceae, Icacinaceae, Vitaceae, Myrtaceae, Selaginellaceae,

Schizaceae, Adiantaceae, Marattiaceae, Dilleniaceae, Sapindaceae, Anacardiaceae, Polygalaceae, Solanaceae, Asclepiadaceae, Davalliaceae, Cleomaceae, Guttiferae, Passifloraceae, Myristicaceae, Musaceae, Marattiaceae, Burseraceae, Cecropiaceae, Schrophulariaceae, Combretaceae and Loganiaceae. These families among other families in the project area are typical of fallowed secondary vegetation. Geomorphologically, the edaphic and topographic status shows that the site is ecologically characterized by sandy-loam soil.

The environment has witnessed various forms of anthropogenic activities such as farm land / settlement, residential houses, industrial activities and other developmental strives. Though primarily a virgin forest of various vegetation strata, heterogeneous in structures and nature, the effect of these forms of activities resulted to some level of ecological succession which, have consequently left the area with some form of irregular vegetation features and thus can best be categorized as a lowland secondary mosaic forest as described by Hopkin [14] for a low land secondary vegetation system. Despite such ecological succession by anthropogenic influences and natural selection under local environmental condition, the vegetation can still be described as rainforest vegetation in relation to similar view of vegetation analysis by SAF [15] and Edwin -Wosu, [5, 16 - 18].

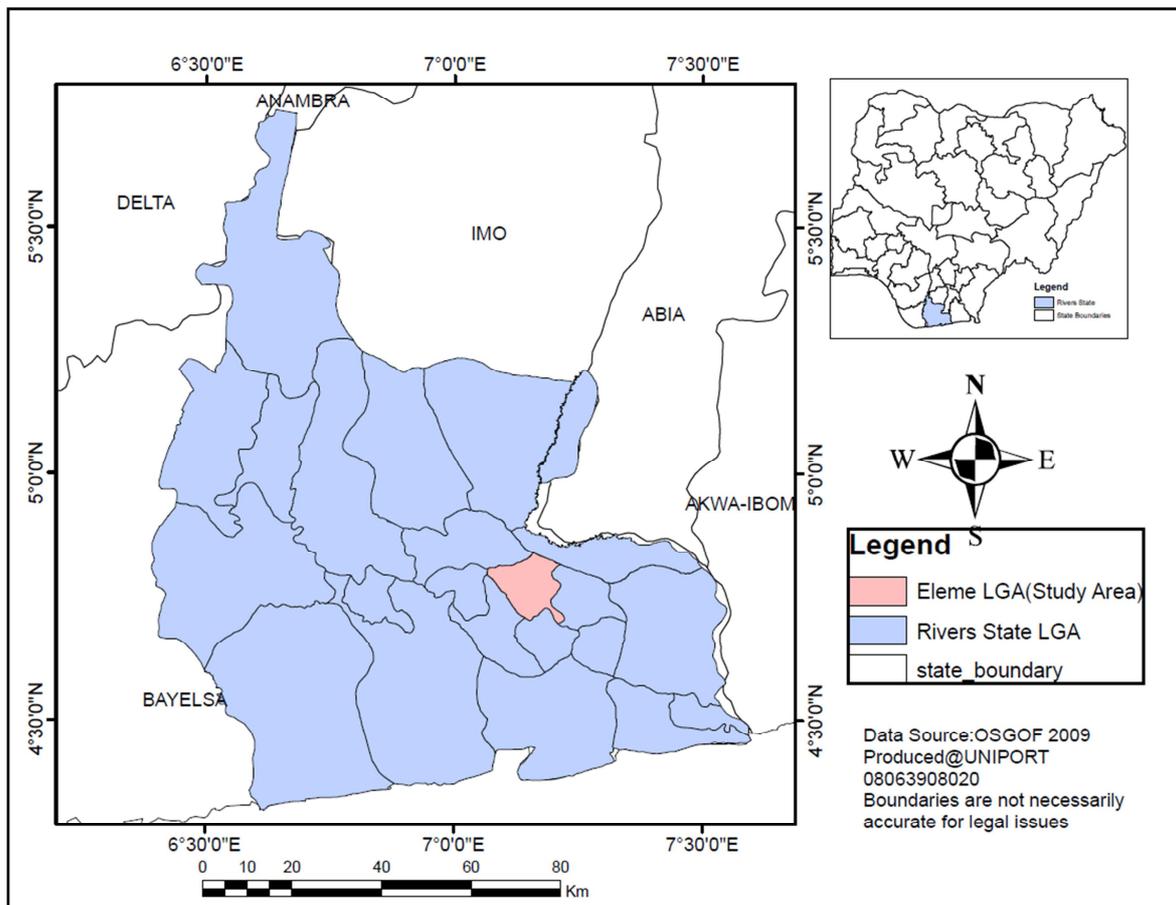


Fig. 1. Rivers State showing Eleme LGA.

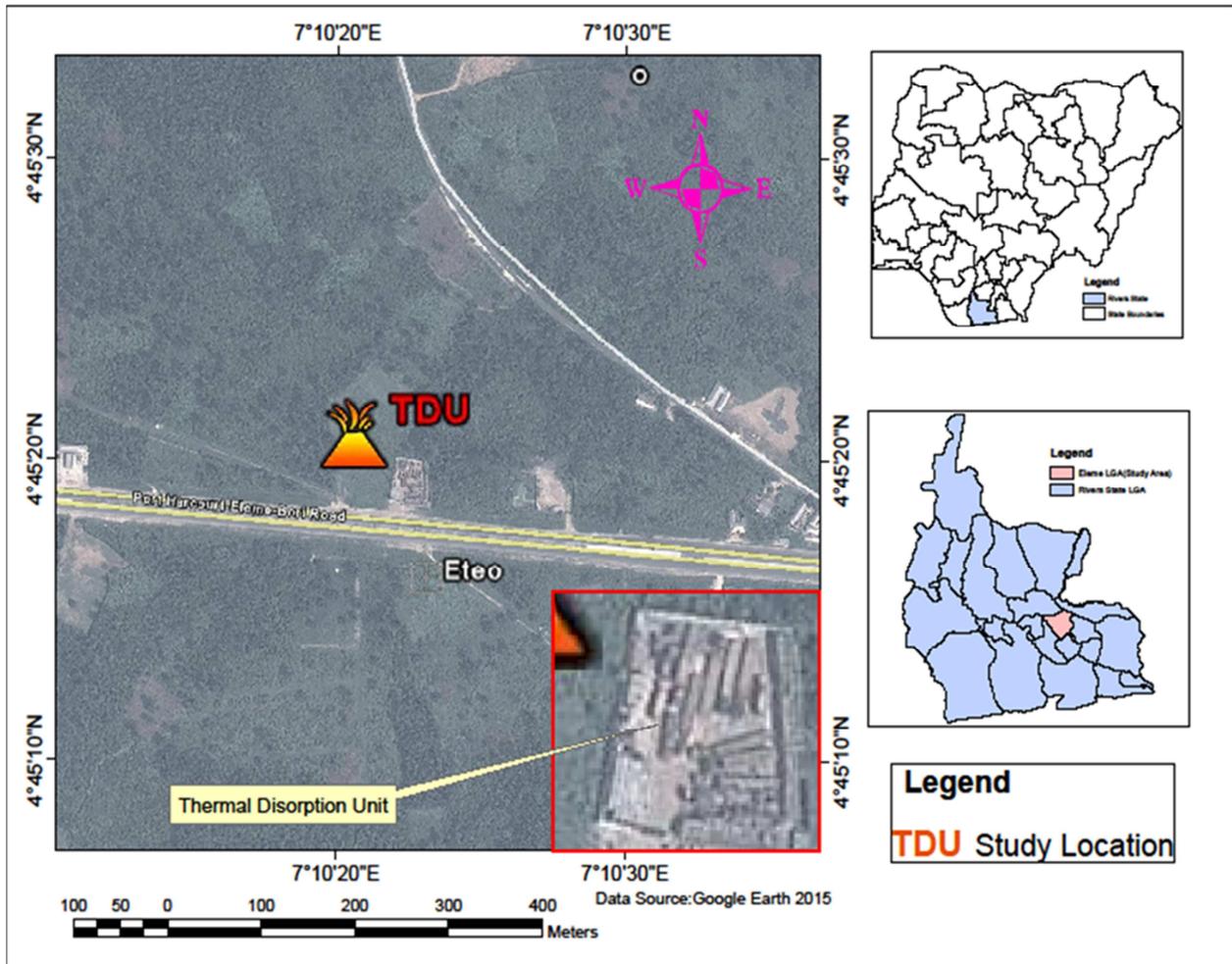


Fig. 2. Study location.

## 2.2. Qualitative and Quantitative Flora Assessment

There are different methods and approaches to environmental impact assessment of development projects. Five major types are commonly used, viz: the checklist, interactive matrices, overlay mapping, network and simulation modeling methods. Based on heterogeneity of the study site and Terms of Reference' (TOR) for the flora biodiversity assessment in line with the irregular physiognomy of the project area, due to human influence, the 'Overlay Mapping method is being adopted using the simple random sampling based on standard procedures for ecological assessment studies [19]. A total of five transect directions in site were systematically sampled. All the important representative plant species sampled were identified in the field as far as possible and were properly authenticated using reference books and Floras such as Burkill, [20 – 24]; Hutchinson and Dalziel, [25-29]; Keay, [30].

## 2.3. Data Analysis

The frequency of distribution, abundance, and density of the most representative species of the area were estimated using the methods of Austin and Greig-Smith [31]; Kershaw [32]; Pryor, [33] and Shukla and Chadel's [34] approach

modified in Bonham [35]. The species diversity over the study area was evaluated using the Shannon-Wiener [36] diversity index. Relative density, relative abundance and relative frequency were estimated following Misra [37] method. While the Importance Value Index (IVI) was estimated by adding the values of RD, RA and RF using the Shukla and Chandel [34] method. The ratio of abundance to frequency for different species was determined for distribution patterns. Thus with the "thumb of rule" designated as follows: *Regular* (<0.03), *random* (0.03 – 0.05), and *contiguous* (>0.05) distribution as adopted by Curtis and Cottam [38]. Similarity index (IS) between the two seasons vegetation complex was derived from the formula given by Sorensen [39].

## 3. Result

### Floristic Structure, Composition and Classification

This wet and dry season report on the TDU study area shows that the area is associated with a flora system characterised by secondary vegetation structure in a closed and spatial horizontal continuum. The area has ordinarily been influenced by anthropogenic incursion such as the springing up of built up areas for residential and industrial purposes, domestic fire wood logging for fuel consumption and also

farmlands by the local inhabitants. The study as observed in Tables 1 and 2 for the TDU operation base had shown that the project sites are richly endowed with floras of various strata and categories belonging to different plant families despite the prevailing influences. The project sites are typical virgin forest though with some levels of secondary heterogeneity as a result of ecological succession incursion by both natural and human factors. Despite the ecological succession, the study area yet contains plant species in various diversity and abundance with representative species recorded.

Though, there were differences in the ranks of species frequency in different transect, the TDU proposed site in wet season recorded a total representative of 102 species under 39 families in mosaic heterogeneity (Table 1a). Twelve families were prevalently dominant in which 9 families (*Euphorbiaceae*, *Fabaceae*, *Araceae*, *Apocynaceae*, *Malvaceae*, *Rubiaceae*, *Passifloraceae*, *Asteraceae* and *Cyperaceae*) were very abundant while three families (*Loganiaceae*, *Poaceae* and *Commelinaceae*) were in abundance. Among the dominant families, *Euphorbiaceae* recorded the highest species diversity in terms of richness with 13 species followed by *Fabaceae* (7 Species), *Rubiaceae* and *Asteraceae* had 6 species respectively while *Cyperaceae* had 5 species. In dry season a total of 59 representative species in 30 families were recorded (Table 2a). Nine families were prevalently dominant with five species (*Apocynaceae*, *Malvaceae*, *Rubiaceae*, *Poaceae* and *Asteraceae*) very abundant and four species (*Euphorbiaceae*, *Fabaceae*, *Tiliaceae* and *Cyperaceae*) in abundance. Among the dominant families *Poaceae* and *Asteraceae* were richest with five species each. Under such ecological assessment there was increase in the herbaceous status of habit and life form with the most representative dominant species in the study site as herbs distributed among the 39 and 30 families in wet and dry season respectively.

Phytosociological assessment of species prevalence around the TDU proposed site shows that among the representative species (Table 1b) in wet season, 18 species had the highest frequency occurrence of 100 = 1.61% while the density showed 49 species with maximum range value of 10 – 60 = 0.80 – 4.80% with the highest density value of 60 = 4.80% recorded with *Manihot esculenta* (cassava). A total of 76 species had maximum abundance with a range value of 10 – 100 (0.50 – 4.98%) in which *Urena lobata* and *Oldenlandia herbacea* recorded the highest abundance values of 100 = 4.98% respectively, while *Oldenlandia herbacea* have shown dominance with Important Value Index of 8.82%. Species diversity is one of the major criteria in recognising the importance of an area for conservation priority. The diversity of species in the study area has shown some degree of variation in flora richness and evenness among representative samples. Result showed that cassava and *Oldenlandia herbacea* recorded the highest diversity with Index Value of 0.05 richness and 0.02 evenness respectively among representative with maximum value range of 0.04 – 0.05 richness and 0.02 evenness. The ratio of abundance to frequency showed that the species of the study area were

mostly contiguous in distribution pattern with a spatial continuum of 98 (96.08%) species while 3 (2.94%) and 1 (1.0%) were regularly and randomly distributed respectively (Fig. 3). Generally, in all bounding coordinate within the study site there was increase in herbaceous status in terms of habit with a representative total of 54 (52.94%) species as herbs, 38 (37.26%) as shrubs and 10 (9.8%) as trees (Fig. 4).

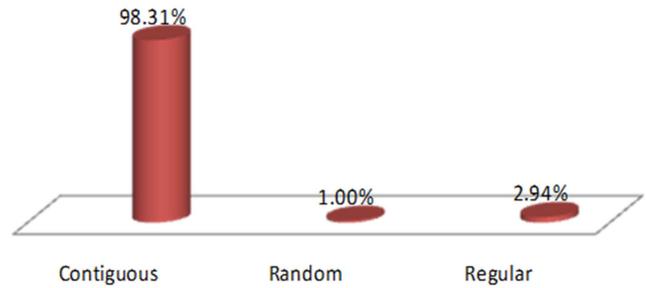


Fig. 3. Wet season distribution pattern of species.

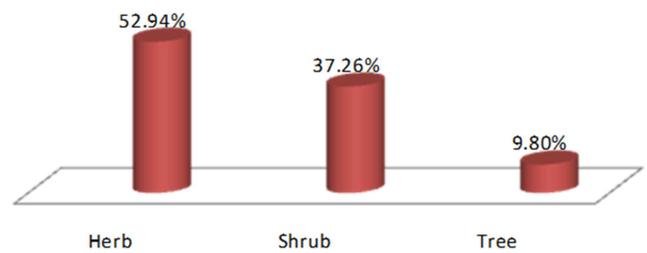


Fig. 4. Wet season life form of species.

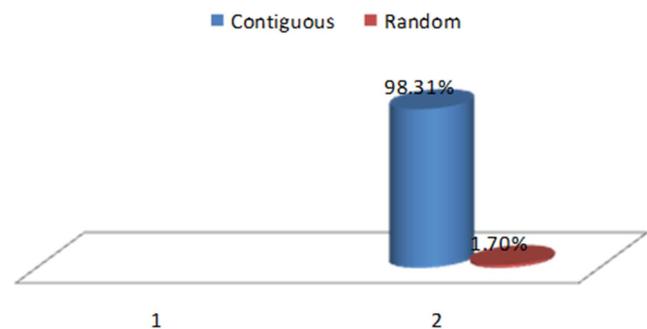


Fig. 5. Dry season distribution pattern of species

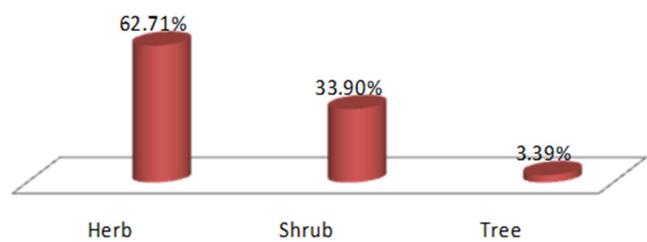


Fig. 6. Dry season life form of species.

In dry season one species (*H. rotundifolia*) had the highest frequency of 100 = 5.05%, while 18 species recorded maximum density range of 10 – 40 = 2.04 – 1.22% with carpet grass having the highest density. Fourty one species had maximum abundance range of 10 – 80 = 0.90 – 7.23% with *P. indica* having the highest abundance of 80 = 7.23%. The

highest IVI of 16.71% was recorded by carpet grass, with highest diversity of 0.07 richness and 0.04 evenness. The distribution pattern had 58 (98.31%) species with contiguous and one (1.70%) as random distribution (Fig. 5), while life form habit had 37 (62.71%) as herbs, 20 (33.90%) as shrubs and 2 (3.39%) as trees (Table 2b) (Fig. 6). Despite the variation in season, on the basis of similarity in species

composition of the vegetation structure the site recorded maximum similarity of 56%.

Generally, the plant species in the project location were not remarkably infected with pathogens when compared to the apparent observation of leaf sports, die back, leaf blotch, dry rot, stem rot, stem corky and fungi and mushroom infestation as at the period of sampling.

**Table 1A.** Wet season Survey Estimate of Representative Species around the TDU proposed site.

S/N	Species	%F	Family	Habit	Common Name	Remark
1	<i>Alchornea cordifolia</i> (Schum & Thonn) Mull – Arg.	80	Euphorbiaceae	Shrub	Christmas bush	++++
2	<i>Mallotus subulatus</i> Mull – Arg.	100	Euphorbiaceae	Shrub	Kamala plant	+++++
3	<i>Mallotus oppositifolus</i> (Geisel) Mull – Arg	60	Euphorbiaceae	Shrub	Kamala plant	+++
4	<i>Cnestis ferruginea</i> DC	40	Connaraceae	Shrub	NA	++
5	<i>Smilax anceps</i> Willd.	40	Smilacaceae	Herb	West African sarsaparilla	++
6	<i>Anthoantha macrophylla</i> P. Beauv.	100	Fabaceae-caesal.	Shrub	West African rose wood	+++++
7	<i>Anthoantha obanensis</i> (Bak.f.) J. Leonard	100	Fabaceae-caesal.	Shrub	West African rose wood	+++++
8	<i>Anchormanis difformis</i> (Bl.) Engl.	80	Araceae	Shrub	Forest Anchormanis	++++
9	<i>Milletia aboensis</i> (Hook. f.) Bak.	60	Fabaceae	Shrub	Fermentation plant	+++
10	<i>Icacina trichantha</i> Oliv.	60	Icacinaceae	Herb	NA	+++
11	<i>Voacanga africana</i> Stapf.	80	Apocynaceae	Shrub	NA	++++
12	<i>Urena lobata</i> Linn.	20	Malvaceae	Shrub	NA	+
13	<i>Oldenlandia corymbosa</i> Linn.	60	Rubiaceae	Herb	Mille - grains	+++
14	<i>Icacina mannii</i> Oliv.	20	Icacinaceae	Herb	NA	+
15	<i>Barteria nigritiana</i> Hook. f.	80	Passifloraceae	Shrub	NA	++++
16	<i>Elaeis guineensis</i> Jacq	100	Arecaceae	Tree	Oil palm tree	+++++
17	<i>Anthocleista vogelii</i> Planch.	80	Loganiaceae	Tree	Cabbage tree	++++
18	<i>Anthocleista djalonesis</i> A. Chev.	80	Loganiaceae	Tree	Cabbage tree	++++
19	<i>Harrungana madagascariensis</i> Ham ex Pour	100	Guttiferae	Shrub	Dragon's blood	+++++
20	<i>Rauvolfia vomitoria</i> Afzel.	80	Apocynaceae	Shrub	Swizzle stick	++++
21	<i>Bambusa vulgaris</i> Schrad.	60	Poaceae	Tree	Indian bamboo	+++
22	<i>Alchornea laxiflora</i> (Benth.) Pax & K. Hoffm.	80	Euphorbiaceae	Shrub	Christmas bush	++++
23	<i>Manniophyton fulvum</i> Mull – Arg.	20	Euphorbiaceae	Shrub	NA	+
24	<i>Hibiscus surratensis</i> Linn.	20	Malvaceae	Herb	Bush sorrel	+
25	<i>Palisota hirsuta</i> (Thunb.) K. Schum.	80	Commelinaceae	Shrub	NA	++++
26	<i>Palisota ambigua</i> (P. Beauv.) C.B. Cl.	60	Commelinaceae	Shrub	NA	+++
27	<i>Costus lucanusianus</i> J. Braun & K. Schum.	80	Costaceae	Shrub	Ginger lily	++++
28	<i>Costus afer</i> Ker – Gawl.	80	Costaceae	Shrub	Bush cane	++++
29	<i>Anthoeleista nobilis</i> G. Don	40	Longaniaceae	Tree	Cabbage plant	++
30	<i>Vitex doniana</i> Sweet.	20	Vitaceae	Shrub	Black plum	+
31	<i>Funfumia africana</i> (Benth.) Stapf.	60	Apocynaceae	Shrub	NA	+++
32	<i>Anchormanis giganteus</i> Engl.	80	Araceae	Herb	Giant Anchormanis	++++
33	<i>Psidium guajava</i> Linn	60	Myrtaceae	Shrub	Guava	+++
34	<i>Maesobotrya barteri</i> (Baill) Hutch.	40	Euphorbiaceae	Shrub	Bush cherry	++
35	<i>Griffordia physocarpa</i> Baill.	40	Fabaceae	Tree	NA	++
36	<i>Selaginella myosurus</i> (SW.) Alston.	100	Selaginellaceae	Herb	Fern	+++++
37	<i>Lygodium macrophyllum</i>	100	Schizaceae	Herb	Fern	+++++
38	<i>Senna hirsuta</i> (Linn.) Irwin & Barneby	80	Fabaceae-ceasal	Shrub	Senna	++++
39	<i>Manihot esculenta</i> Crantz	100	Euphorbiaceae	Shrub	Cassava	+++++
40	<i>Pteris acanthonura</i>	20	Adiantaceae	Herb	Fern	+
41	<i>Cissus aralioides</i> (Welw.) Planch.	60	Vitaceae	Herb	NA	+++
42	<i>Stachytarpheta cayennensis</i> (LC Rich.) Schau.	80	Verbenaceae	Shrub	Rat tail	++++
43	<i>Melastomastrum capitatum</i> (Vahl.) A & R. Fernandes	40	Melastomataceae	Shrub	NA	++
44	<i>Antidesma vogelianum</i> Mull- Arg.	40	Euphorbiaceae	Shrub	NA	++
45	<i>Glyphea brevis</i> (Spreng) Monachino	40	Tiliaceae	Shrub	NA	++
46	<i>Craterispermum cerrunanthum</i> Hiern.	60	Rubiaceae	Shrub	NA	+++
47	<i>Craterispermum caudatum</i>	60	Rubiaceae	Shrub	NA	+++

S/N	Species	%F	Family	Habit	Common Name	Remark
48	<i>Macaranga barteri</i> Mull – Arg.	80	Euphorbiaceae	Shrub	NA	++++
49	<i>Macaranga spinosa</i> Mull – Arg.	80	Euphorbiaceae	Shrub	NA	++++
50	<i>Bridella ferruginea</i> Benth.	60	Euphorbiaceae	Shrub	NA	+++
51	<i>Bridella grandis</i> Pierre	60	Euphorbiaceae	Tree	NA	+++
52	<i>Paullina pinnata</i> Linn.	100	Sapindaceae	Herb	Bread & Cheese	+++++
53	<i>Tetracera alnifolia</i>	20	Dilleniaceae	Herb	Liane cord	+
54	<i>Spondias mombin</i> Linn.	40	Anarcardiaceae	Tree	Hog plum	++
55	<i>Rhektophyllum mrabile</i> N.E. Br.	60	Araceae	Herb	Bush cocoyam	+++
56	<i>Smeathmania pubescens</i> Soland.	40	Passifloraceae	Tree	NA	++
57	<i>Carpoloba leutea</i> G.Don.	20	Polygalaceae	Shrub	Poor man's candle	+
58	<i>Physallis angulata</i> Linn	40	Solanaceae	Herb	Angular water cherry	++
59	<i>Triumfetta cordifolia</i> A.Rich.	100	Tiliaceae	Herb	Bur weed	+++++
60	<i>Ipomoea involucrata</i> P. Beauv.	20	Convolvulaceae	Herb	Morning glory	+
61	<i>Landolphia dulcis</i> (R. Br) Pichon	20	Apocynaceae	Herb	Rubber vine	+
62	<i>Stachytarpheta jamaicensis</i> Vahl.	60	Verbenaceae	Shrub	Brazilian tea	+++
63	<i>Albizia lebeck</i> (Linn.) Benth.	40	Fabaceae - mimo	Tree	Women tongue	++
64	<i>Pergularia daemia</i> (Forssk.) Chiov.	20	Asclepiadaceae	Herb	NA	+
65	<i>Adenia labata</i> (Jacq) Engl.	20	Passifloraceae	Herb	NA	+
66	<i>Adenia caesampeloides</i> (Planch) Harms	40	Passifloraceae	Herb	NA	++
67	<i>Lonchocarpus sericeus</i> (Poir) HB & K	20	Fabaceae - papi	Shrub	Cube root	+
68	<i>Mussaenda landolphioides</i> Wernham	40	Rubiaceae	Herb	NA	++
69	<i>Marattia fraxinea</i>	100	Marattiaceae	Herb	Fern	+++++
70	<i>Ficus exasperata</i> Vahl.	20	Moraceae	Shrub	Sand paper plant	+
71	<i>Panicum maximum</i> Jacq	100	Poaceae	Herb	Guinea grass	+++++
72	<i>Aspilla bussei</i> O. Hoffin & Muschl	100	Asteraceae	Herb	White hemorrhage	+++++
73	<i>Sida rhombifolia</i> Linn.	100	Malvaceae	Herb	Wire weed	+++++
74	<i>Sida garkaena</i> Polak	100	Malvaceae	Herb	Broom weed	+++++
75	<i>Conyzia summatrensis</i> (Retz) Walker	20	Asteraceae	Herb	Fleabane	+
76	<i>Nephrolepis pumicola</i>	100	Davalliaceae	Herb	Fern	+++++
77	<i>Nephrolepis bisserata</i>	100	Davalliaceae	Herb	Fern	+++++
78	<i>Cleom rotidosperma</i> DC.	40	Cleomaceae	Herb	Spider flower	++
79	<i>Chromotaena odorata</i> (Linn) RM King & Robinson	40	Asteraceae	Herb	Siam weed	++
80	<i>Aspilla africana</i> (Pers) CD Adams.	60	Asteraceae	Herb	Heamorrhage plant	+++
81	<i>Ageratum conyzoides</i> Linn.	60	Asteraceae	Herb	Goat weed	+++
82	<i>Solenostemon monostachyus</i> (P. Beauv.) Brig.	20	Lamiaceae	Herb	NA	+
83	<i>Phyllanthus amarus</i> Schum & Thonn.	60	Euphorbiaceae	Herb	Chanca	+++
84	<i>Spermacoce ocymoides</i> Burm f.	40	Rubiaceae	Herb	False button weed	++
85	<i>Heterotis rotundifolia</i> (Sm.) Jac. Fel.	100	Melastomataceae	Herb	Cheek weed	+++++
86	<i>Cyathula prostrata</i> (L.) Blums.	80	Amaranthaceae	Herb	Cyathule	++++
87	<i>Archyranthes aspera</i> Linn.	60	Acanthaceae	Herb	Devil horsewhip	+++
88	<i>Lapistemon owariensis</i> (P. Beauv.) Hallier. f.	40	Covolvulaceae	Herb	NA	++
89	<i>Plastoma africanum</i> P. Beauv.	60	Lamiaceae	Herb	NA	+++
90	<i>Spillanthes filicaulis</i> (Schum & Thonn.) CD Adams	80	Asteraceae	Herb	Brazil cress	++++
91	<i>Mariscus longbreateatus</i> Cherm.	40	Cyperaceae	Herb	Sedge	++
92	<i>Mariscus flabelliformis</i> Kunth.	40	Cyperaceae	Herb	Sedge	++
93	<i>Kyllinga bulbosa</i> Beauv,	60	Cyperaceae	Herb	Sedge	+++
94	<i>Asystasia gagentica</i> (Linn.) T. Anders.	60	Acanthaceae	Herb	NA	+++
95	<i>Alternanthera sessilis</i> (Linn.) DC.	80	Amarantheceae	Herb	Sessile joyweed	++++
96	<i>Anchormanus giganteus</i> Engl.	80	Araceae	Herb	Giant Anchormanus	++++
97	<i>Aneilema beniniense</i> (P. Beauv.) Kunth	80	Commelinaceae	Herb	NA	++++
98	<i>Mariscus alternifolius</i> Vahl.	60	Cyperaceae	Herb	Sedge	+++
99	<i>Perotis indica</i> (Linn.) O. Ktze	80	Poaceae	Herb	Grass	++++
100	<i>Oplimemus baumanii</i> (Retz) P. Beauv.	80	Poaceae	Herb	Grass	++++
101	<i>Oldenlandia herbacea</i> (Linn.) Roxb	40	Rubiaceae	Herb	NA	++
102	<i>Cypenes rotundus</i> Linn.	40	Cyperaceae	Herb	Purple nutsedge	++

Note: + (1-25) Very scarce, ++ (26-59) Scarce, +++ (60-79) Abundant, ++++> (80-α) Very abundant, NA- Not available, %F- Percentage frequency.

Table 1B. Wet Season Quantitative List of Representative Species around the TDU proposed site.

S/N	Species	%F	D	A	%RF	%RD	%RA	IVI	SDR	SDE	A/F
1	<i>Alchornea cordifolia</i> (Schum & Thonn) Mull – Arg.	80	20	25	1.29	1.60	1.25	4.14	0.03	0.01	0.31
2	<i>Mallotus subulatus</i> Mull – Arg.	100	10	10	1.61	0.80	0.50	2.91	0.02	0.01	0.10
3	<i>Mallotus oppositifolus</i> (Geisel) Mull – Arg	60	14	23.3	0.96	1.12	1.16	3.24	0.02	0.01	0.38
4	<i>Cnestis ferruginea</i> DC	40	6	15	0.64	0.48	0.75	1.87	0.01	0.01	0.38
5	<i>Smilax anceps</i> Willd.	40	3	7.5	0.64	0.24	0.37	1.25	0.01	0.01	0.19
6	<i>Anthonotha macrophylla</i> P. Beauv.	100	20	20	1.61	1.60	1.00	4.21	0.03	0.01	0.20
7	<i>Anthonotha obanensis</i> (Bak. f.) J. Leonard	100	20	20	1.61	1.60	1.00	4.21	0.03	0.01	0.20
8	<i>Anchormanis difformis</i> (Bl.) Engl.	80	12	15	1.29	0.96	0.75	3.00	0.02	0.01	0.19
9	<i>Milletia aboensis</i> (Hook. f.) Bak.	60	16	26.7	0.96	1.28	1.33	3.57	0.02	0.01	0.45
10	<i>Icacina trichantha</i> Oliv.	60	6	10	0.96	0.48	0.50	1.94	0.01	0.01	0.17
11	<i>Voacanga africana</i> Stapf.	80	20	25	1.29	1.60	1.25	4.14	0.03	0.01	0.31
12	<i>Urena lobata</i> Linn.	20	20	100	0.32	1.60	4.98	6.90	0.04	0.02	5.00
13	<i>Oldenlandia corymbosa</i> Linn.	60	40	66.7	0.96	3.20	3.32	7.48	0.04	0.02	1.11
14	<i>Icacina manni</i> Oliv.	20	3	15	0.32	0.24	0.75	1.31	0.01	0.01	0.75
15	<i>Barteria nigriflora</i> Hook. f.	80	14	17.5	1.29	1.12	0.87	3.28	0.02	0.01	0.22
16	<i>Elaeis guineensis</i> Jacq	100	20	20	1.61	1.60	1.00	4.21	0.03	0.01	0.20
17	<i>Anthocleista vogelii</i> Planch.	80	2	2.5	1.29	0.16	0.12	1.57	0.01	0.01	0.03
18	<i>Anthocleista djalonesis</i> A. Chev.	80	1	1.3	1.29	0.08	0.06	1.43	0.01	0.01	0.02
19	<i>Harrungana madagascariensis</i> Ham ex Pour	100	20	20	1.61	1.60	1.00	4.21	0.03	0.01	0.20
20	<i>Rauwolfia vomitoria</i> Afzel.	80	14	17.5	1.29	1.12	0.87	3.28	0.02	0.01	0.22
21	<i>Bambusa vulgaris</i> Schrad.	60	16	26.7	0.96	1.28	1.33	3.57	0.02	0.01	0.45
22	<i>Alchornea laxiflora</i> (Benth.) Pax & K. Hoffm.	80	10	12.5	1.29	0.80	0.62	2.71	0.02	0.01	0.16
23	<i>Manniophyton fulvum</i> Mull – Arg.	20	4	20	0.32	0.32	1.00	1.64	0.01	0.01	1.00
24	<i>Hibiscus surratensis</i> Linn.	20	4	20	0.32	0.32	1.00	1.64	0.01	0.01	1.00
25	<i>Palisota hirsuta</i> (Thunb.) K. Schum.	80	20	25	1.29	1.60	1.25	4.14	0.03	0.01	0.31
26	<i>Palisota ambigua</i> (P. Beauv.) C.B. Cl.	60	20	33.3	0.96	1.60	1.66	4.22	0.03	0.01	0.56
27	<i>Costus lucanusianus</i> J. Braun & K. Schum.	80	20	25	1.29	1.60	1.25	4.14	0.03	0.01	0.31
28	<i>Costus afer</i> Ker – Gawl.	80	20	25	1.29	1.60	1.25	4.14	0.03	0.01	0.31
29	<i>Anthoeleista nobilis</i> G. Don	40	3	7.5	0.64	0.24	0.37	1.25	0.01	0.01	0.19
30	<i>Vitex doniana</i> Sweet.	20	2	10	0.32	0.16	0.50	0.98	0.01	0.004	0.50
31	<i>Funfunia africana</i> (Benth.) Stapf.	60	4	10	0.96	0.32	0.33	1.61	0.01	0.01	0.17
32	<i>Anchormanis giganteus</i> Engl.	80	8	5	1.29	0.64	0.50	2.43	0.02	0.01	0.06
33	<i>Psidium guajava</i> Linn	60	6	5	0.96	0.48	0.50	1.49	0.01	0.01	0.08
34	<i>Maesobotrya barteri</i> (Baill) Hutch.	40	2	20	0.64	0.16	0.25	1.05	0.01	0.01	0.50
35	<i>Griffonia physocarpa</i> Baill.	40	2	20	0.64	0.16	0.25	1.05	0.01	0.01	0.50
36	<i>Selaginella myosurus</i> (SW.) Alston.	100	20	7.5	1.61	1.60	1.00	4.21	0.03	0.01	0.08
37	<i>Lygodium macrophyllum</i>	100	20	60	1.61	1.60	1.00	4.21	0.03	0.01	0.06
38.	<i>Senna hirsuta</i> (Linn.) Irwin & Barneby	80	6	20	1.29	0.48	0.37	2.14	0.02	0.01	0.25
39	<i>Manihot esculenta</i> Crantz	100	60	6.7	1.61	4.80	2.99	9.40	0.05	0.02	0.07
40	<i>Pteris acanthonura</i>	20	4	12.5	0.32	0.32	1.00	1.64	0.01	0.01	0.63
41	<i>Cissus aralioides</i> (Welw.) Planch.	60	4	20	0.96	0.32	0.33	1.61	0.01	0.01	0.33
42	<i>Stachytarpheta cayennensis</i> (LC Rich.) Schau.	80	10	5	1.29	0.80	0.62	2.71	0.02	0.01	0.06
43	<i>Melastomastrum capitatum</i> (Vahl.) A & R. Fernandes	40	8	5	0.64	0.64	1.00	2.28	0.02	0.01	0.13
44	<i>Antidesma vogelianum</i> Mull- Arg.	40	2	10	0.64	0.16	0.25	1.05	0.01	0.01	0.25
45	<i>Glyphea brevis</i> (Spreng) Monachino	40	2	10	0.64	0.16	0.25	1.05	0.01	0.01	0.25
46	<i>Craterispermum cerrunanthum</i> Hiern.	60	6	7.5	0.96	0.48	0.50	1.94	0.01	0.01	0.13
47	<i>Craterispermum caudatum</i>	60	6	10	0.96	0.48	0.05	1.94	0.01	0.01	0.17
48	<i>Macaranga barteri</i> Mull – Arg.	80	6	6.7	1.29	0.48	0.37	2.14	0.02	0.01	0.08
49	<i>Macaranga spinosa</i> Mull – Arg.	80	8	10	1.29	0.64	0.50	2.43	0.02	0.01	0.13
50	<i>Bridella ferruginea</i> Benth.	60	4	0.96	0.96	0.32	0.33	1.61	0.01	0.01	0.02
51	<i>Bridella grandis</i> Pierre	60	4	0.96	0.96	0.32	0.33	1.61	0.01	0.01	0.02

S/N	Species	%F	D	A	%RF	%RD	%RA	IVI	SDR	SDE	A/F
52	<i>Paullina pinnata</i> Linn.	100	12	12	1.61	0.96	0.60	3.17	0.02	0.01	0.12
53	<i>Tetracera alnifolia</i>	20	2	10	0.32	0.16	0.50	0.98	0.01	0.004	0.50
54	<i>Spondias mombin</i> Linn.	40	1	2.5	0.64	0.08	0.12	0.84	0.01	0.004	0.06
55	<i>Rhektophyllum mrabile</i> N.E. Br.	60	4	6.7	0.96	0.32	0.33	1.61	0.01	0.01	0.11
56	<i>Smeathmania pubescens</i> Soland.	40	2	5	0.64	0.16	0.25	1.05	0.01	0.01	0.13
57	<i>Carpoloba leutea</i> G.Don.	20	1	5	0.32	0.08	0.25	0.65	0.01	0.003	0.25
58	<i>Physallis angulata</i> Linn	40	2	5	0.64	0.16	0.25	1.05	0.01	0.01	0.13
59	<i>Triumfetta cordifolia</i> A.Rich.	100	6	6	1.61	0.48	0.30	2.39	0.02	0.01	0.06
60	<i>Ipomoea involucrata</i> P. Beauv.	20	2	10	0.32	0.16	0.50	0.98	0.01	0.004	0.50
61	<i>Landolphia dulcis</i> (R. Br) Pichon	20	2	10	0.32	0.16	0.50	0.98	0.01	0.004	0.50
62	<i>Stachytarpheta jamaicensis</i> Vahl.	60	6	10	0.96	0.48	0.50	1.94	0.01	0.01	0.10
63	<i>Albizia lebeck</i> (Linn.) Benth.	40	2	5	0.64	0.16	0.25	1.05	0.01	0.01	0.13
64	<i>Pergularia daemia</i> (Forssk.) Chiov.	20	1	5	0.32	0.08	0.25	0.65	0.01	0.01	0.25
65	<i>Adenia labata</i> (Jacq) Engl.	20	1	5	0.32	0.08	0.25	0.65	0.01	0.003	0.25
66	<i>Adenia caesampeloides</i> (Planch) Harms	40	1	2.5	0.64	0.08	0.12	0.84	0.01	0.004	0.06
67	<i>Lonchocarpus sericeus</i> (Poir) HB & K	20	2	10	0.32	0.16	0.50	0.98	0.01	0.004	0.50
68	<i>Mussaenda landolphioides</i> Wernham	40	4	10	0.64	0.32	0.50	1.46	0.01	0.01	0.25
69	<i>Marattia fraxinea</i>	100	20	20	1.61	1.6	1.00	4.21	0.03	0.01	0.20
70	<i>Ficus exasperata</i> Vahl.	20	1	5	0.32	0.08	0.25	0.65	0.01	0.003	0.25
71	<i>Panicum maximum</i> Jacq	100	40	40	1.61	3.20	1.99	6.80	0.04	0.02	0.40
72	<i>Aspilla bussei</i> O. Hoffm & Muschl	100	20	20	1.61	1.60	1.00	4.21	0.03	0.01	0.20
73	<i>Sida rhombifolia</i> Linn.	100	20	20	1.61	1.60	1.00	4.21	0.03	0.01	0.20
74	<i>Sida garkaena</i> Polak	100	20	20	1.61	1.60	1.00	4.21	0.03	0.01	0.20
75	<i>Conyza summatrensis</i> (Retz) Walker	20	2	10	0.32	0.16	0.50	0.98	0.01	0.004	0.50
76	<i>Nephrolepis pumicola</i>	100	20	20	1.61	1.60	1.00	4.21	0.03	0.01	0.20
77	<i>Nephrolepis bisserata</i>	100	24	24	1.61	1.92	1.20	4.73	0.03	0.02	0.24
78	<i>Cleom rotidosperma</i> DC.	40	10	25	0.64	0.80	1.25	2.69	0.02	0.01	0.63
79	<i>Chromotaena odorata</i> (Linn) RM King & Robinson	40	20	50	0.64	1.60	2.49	4.73	0.03	0.02	1.25
80	<i>Aspilla africana</i> (Pers) CD Adams.	60	40	66.7	0.96	3.20	3.32	7.48	0.04	0.02	1.11
81	<i>Ageratum conyzoides</i> Linn.	60	10	16.7	0.96	0.80	0.83	2.59	0.02	0.01	0.28
82	<i>Solenostemon monostachyus</i> (P. Beauv.) Brig.	20	6	30	0.32	0.48	1.50	2.30	0.02	0.01	1.50
83	<i>Phyllanthus amarus</i> Schum & Thonn.	60	20	33.3	0.96	1.60	1.66	4.22	0.03	0.01	0.56
84	<i>Spermacocce ocyroides</i> Burm f.	40	12	30	0.64	0.96	1.50	3.10	0.02	0.01	0.75
85	<i>Heterotis rotundifolia</i> (Sm.) Jac. Fel.	100	20	20	1.61	1.60	1.00	4.21	0.03	0.01	0.20
86	<i>Cyathula prostrata</i> (L.) Blums.	80	16	20	1.29	1.28	1.00	3.57	0.02	0.01	0.25
87	<i>Archyranthes aspera</i> Linn.	60	20	33.3	0.96	1.60	1.66	4.22	0.03	0.01	0.56
88	<i>Lapistemon owariensis</i> (P. Beauv.) Hallier .f.	40	6	15	0.64	0.48	0.75	1.87	0.01	0.01	0.38
89	<i>Plastosma africanum</i> P. Beauv.	60	8	13.3	0.96	0.64	0.66	2.26	0.02	0.01	0.22
90	<i>Spillanthes filicaulis</i> (Schum & Thonn.) CD Adams	80	20	25	1.29	1.60	1.25	4.14	0.03	0.01	0.31
91	<i>Mariscus longbreateatus</i> Cherm.	40	8	20	0.64	0.64	1.00	2.28	0.02	0.01	0.50
92	<i>Mariscus flabelliformis</i> Kunth.	40	8	20	0.64	0.64	1.00	2.28	0.02	0.01	0.50
93	<i>Kyllinga bulbosa</i> Beauv,	60	12	20	0.96	0.96	1.00	2.92	0.02	0.01	0.33
94	<i>Asystasia gagentica</i> (Linn.) T. Anders.	60	6	10	0.96	0.48	0.50	1.94	0.01	0.01	0.17
95	<i>Alternanthera sessilis</i> (Linn.) DC.	80	20	25	1.29	1.60	1.25	4.14	0.03	0.01	0.31
96	<i>Anchormanis giganteus</i> Engl.	80	6	7.5	1.29	0.48	0.37	2.14	0.02	0.01	0.08
97	<i>Aneilema beniniense</i> (P. Beauv.) Kunth	80	12	15	1.29	0.96	0.75	3.00	0.02	0.01	0.19
98	<i>Mariscus alternifolius</i> Vahl.	60	20	33.3	0.96	1.60	1.66	4.22	0.03	0.01	0.56
99	<i>Perotis indica</i> (Linn.) O. Ktze	80	40	50	1.29	3.20	2.49	6.98	0.04	0.02	0.63
100	<i>Oplimenus baumanii</i> (Retz) P. Beauv.	80	40	50	1.29	3.20	2.49	6.98	0.04	0.02	0.63
101	<i>Oldenlandia herbacea</i> (Linn.) Roxb	40	40	100	0.64	3.20	4.98	8.82	0.05	0.02	2.50
102	<i>Cypenes rotundus</i> Linn.	40	20	50	0.64	1.60	2.49	4.73	0.03	0.02	1.25
		6220	1250	2006.1				299.92			

Table 2A. Dry Season Survey Estimate of Representative Species around the TDU proposed site.

S/N	Species	%F	Family	Habit	Common Name	Remark
1.	<i>Mallotus subulatus</i> Mull – Arg.	60	Euphorbiaceae	Shrub	Kamala plant	+++
2.	<i>Mallotus oppositifolius</i> (Geisel) Mull – Arg	40	Euphorbiaceae	Shrub	Kamala plant	++
3.	<i>Cnestis ferruginea</i> DC	20	Connaraceae	Shrub	NA	+
4.	<i>Smilax anceps</i> Willd.	20	Smilacaceae	Herb	West African sarsaparilla	+
5.	<i>Anthonotha macrophylla</i> P. Beauv.	60	Fabaceae-caesal.	Shrub	West African rose wood	+++
6.	<i>Anthonotha obanensis</i> (Bak.f.) J. Leonard	40	Fabaceae-caesal.	Shrub	West African rose wood	++
7.	<i>Anchormanis difformis</i> (Bl.) Engl.	80	Araceae	Shrub	NA	++++
8.	<i>Milletia aboensis</i> (Hook. f.) Bak.	20	Fabaceae	Shrub	Fermentation plant	+
9.	<i>Icacina trichantha</i> Oliv.	20	Icacinaceae	Herb	NA	+
10.	<i>Voacanga africana</i> Stapf.	60	Apocynaceae	Shrub	NA	+++
11.	<i>Urena lobata</i> Linn.	40	Malvaceae	Shrub	NA	++
12.	<i>Barteria nigritiana</i> Hook. f.	40	Passifloraceae	Shrub	NA	++
13.	<i>Anthocleista vogelii</i> Planch.	20	Loganiaceae	Tree	Cabbage tree	+
14.	<i>Rauvolfia vomitoria</i> Afzel.	40	Apocynaceae	Shrub	Swizzle stick	++
15.	<i>Alchornea laxiflora</i> (Benth.) Pax & K. Hoffm.	40	Euphorbiaceae	Shrub	Christmas bush	++
16.	<i>Hibiscus surratensis</i> Linn.	20	Malvaceae	Herb	Bush sorrel	+
17.	<i>Palisota hirsuta</i> (Thunb.) K. Schum.	40	Commelinaceae	Shrub	NA	++
18.	<i>Palisota ambigua</i> (P. Beauv.) C.B. Cl.	40	Commelinaceae	Shrub	NA	++
19.	<i>Costus lucanusianus</i> J. Braun & K. Schum.	40	Costaceae	Shrub	Ginger lily	++
20.	<i>Anthocleista nobilis</i> G. Don	20	Loganiaceae	Tree	Cabbage plant	+
21.	<i>Psidium guajava</i> Linn	60	Myrtaceae	Shrub	Guava	+++
22.	<i>Selaginella myosurus</i> (SW.) Alston.	80	Selaginellaceae	Herb	Fern	++++
23.	<i>Craterispermum cerrinanthum</i> Hiern.	40	Rubiaceae	Shrub	NA	++
24.	<i>Carpoloba leutea</i> G.Don.	20	Polygalaceae	Shrub	Poor man's candle	+
25.	<i>Triumfetta cordifolia</i> A.Rich.	80	Tiliaceae	Herb	Bur weed	++++
26.	<i>Ipomoea involucreta</i> P. Beauv.	20	Convolvulaceae	Herb	Morning glory	+
27.	<i>Landolphia dulcis</i> (R. Br) Pichon	20	Apocynaceae	Herb	Rubber vine	+
28.	<i>Marattia fraxinea</i>	60	Marattiaceae	Herb	Fern	+++
29.	<i>Panicum maximum</i> Jacq	80	Poaceae	Herb	Guinea grass	++++
30.	<i>Sida rhombifolia</i> Linn.	80	Malvaceae	Herb	Wire weed	++++
31.	<i>Nephrolepis bisserata</i>	80	Davalliaceae	Herb	Fern	++++
32.	<i>Cleom rotidosperma</i> DC.	20	Cleomaceae	Herb	Spider flower	+
33.	<i>Chromolaena odorata</i> (Linn) RM King & Robinson	60	Asteraceae	Herb	Siam weed	+++
34.	<i>Aspilla africana</i> (Pers) CD Adams.	40	Asteraceae	Herb	Heamorrhage plant	++
35.	<i>Heterotis rotundifolia</i> (Sm.) Jac. Fel.	100	Melastomataceae	Herb	Cheek weed	+++++
36.	<i>Platostoma africanum</i> P. Beauv.	20	Lamiaceae	Herb	NA	+
37.	<i>Spillanthes filicaulis</i> (Schum & Thonn.) CD Adams	40	Asteraceae	Herb	Brazil cress	++
38.	<i>Mariscus longbreateatus</i> Cherm.	20	Cyperaceae	Herb	Sedge	+
39.	<i>Mariscus flabelliformis</i> Kunth.	20	Cyperaceae	Herb	Sedge	+
40.	<i>Asystasia gagentica</i> (Linn.) T. Anders.	20	Acanthaceae	Herb	NA	+
41.	<i>Alternanthera sessilis</i> (Linn.) DC.	40	Amarantheceae	Herb	Sessile joyweed	++
42.	<i>Anchormanis giganteus</i> Engl.	20	Araceae	Herb	NA	+
43.	<i>Mariscus alternifolius</i> Vahl.	60	Cyperaceae	Herb	Sedge	+++
44.	<i>Perotis indica</i> (Linn.) O. Ktze	40	Poaceae	Herb	Grass	++
45.	<i>Oplimemus baumanii</i> (Retz) P. Beauv.	60	Poaceae	Herb	Grass	+++
46.	<i>Diodia sermentosa</i>	60	Rubiaceae	Herb	NA	+++
47.	<i>Triumfetta rhomboidea</i>	40	Tiliaceae	Herb	NA	++
48.	<i>Vernonia cineria</i>	20	Asteraceae	Herb	Bouton violet	+
49.	<i>Mitracarpus scarba</i>	60	Rubiaceae	Herb	NA	+++
50.	<i>Spermaccoci verticillata</i>	40	Rubiaceae	Herb	NA	++
51.	<i>Axonopus compressus</i>	80	Poaceae	Herb	Carpet grass	++++
52.	<i>Emilia sonchifolia</i>	20	Asteraceae	Herb	Lilac tassel flower	+
53.	<i>Aframommum danielli</i>	40	Zingiberaceae	Herb	Bastard meleguatta	++
54.	<i>Triumfetta eriophlebia</i>	40	Tiliaceae	Herb	NA	++
55.	<i>Funtumia africana</i>	20	Apocunaceae	Shrub	NA	+
56.	<i>Sida acuta</i>	40	Malvaceae	Herb	Broom weed	++
57.	<i>Digitaria horizontalis</i>	60	Poaceae	Herb	Digit grass	+++
58.	<i>Newbouldia laevis</i>	20	Bignoniaceae	Shrub	Man's tree	+
59.	<i>Lagenaria guineensis</i>	60	Cucurbitaceae	Herb	NA	+++

Table 2B. Dry Season Quantitative List of Representative Species around the TDU proposed site.

S/N	Species	%F	D	A	%RF	%RD	%RA	IVI	SDR	SDE	A/F
1	<i>Mallotus subulatus</i> Mull – Arg.	60	4	6.7	3.03	0.82	0.61	4.46	0.03	0.02	0.11
2	<i>Mallotus oppositifolius</i> (Geisel) Mull – Arg	40	6	15	2.02	1.22	1.36	4.60	0.03	0.02	0.38
3	<i>Cnestis ferruginea</i> DC	20	2	10	1.01	0.41	0.90	2.32	0.02	0.01	0.50
4	<i>Smilax anceps</i> Willd.	20	2	10	1.01	0.41	0.90	2.32	0.02	0.01	0.50
5	<i>Anthonotha macrophylla</i> P. Beauv.	60	6	10	3.03	1.22	0.90	5.15	0.03	0.02	0.17
6	<i>Anthonotha obanensis</i> (Bak.f.) J. Leonard	40	3	7.5	2.02	0.61	0.68	3.31	0.02	0.01	0.19
7	<i>Anchormanis difformis</i> (Bl.) Engl.	80	2	2.5	4.04	0.41	0.23	4.68	0.03	0.02	0.03
8	<i>Milletia aboensis</i> (Hook. f.) Bak.	20	7	35	1.01	1.43	3.16	5.60	0.03	0.02	1.75
9	<i>Icacina trichantha</i> Oliv.	20	1.6	8	1.01	0.33	0.72	2.06	0.01	0.01	0.40
10	<i>Voacanga africana</i> Stapf.	60	4	6.7	3.03	0.82	0.61	4.46	0.03	0.02	0.11
11	<i>Urena lobata</i> Linn.	40	2	5	2.02	0.41	0.45	2.88	0.02	0.01	0.13
12	<i>Barteria nigritiana</i> Hook. f.	40	5	12.5	2.02	1.02	1.13	4.17	0.02	0.01	0.31
13	<i>Anthocleista vogelii</i> Planch.	20	1	5	1.01	0.20	0.45	1.66	0.01	0.01	0.25
14	<i>Rauvolfia vomitoria</i> Afzel.	40	3	7.5	2.02	0.61	0.68	3.31	0.003	0.002	0.19
15	<i>Alchornea laxiflora</i> (Benth.) Pax & K. Hoffm.	40	3	7.5	2.02	0.61	0.68	3.31	0.003	0.002	0.19
16	<i>Hibiscus surratensis</i> Linn.	20	2	10	1.01	0.41	0.90	2.32	0.02	0.01	0.50
17	<i>Palisota hirsuta</i> (Thunb.) K. Schum.	40	8	20	2.02	1.63	1.81	5.46	0.03	0.02	0.50
18	<i>Palisota ambigua</i> (P. Beauv.) C.B. Cl.	40	8	20	2.02	1.63	1.81	5.46	0.03	0.02	0.50
19	<i>Costus lucanusianus</i> J. Braun & K. Schum.	40	6	15	2.02	1.22	1.36	4.60	0.03	0.02	0.38
20	<i>Anthocleista nobilis</i> G. Don	20	1	5	1.01	0.20	0.45	1.66	0.02	0.01	0.25
21	<i>Psidium guajava</i> Linn	60	2	3.3	3.03	0.41	0.30	3.74	0.02	0.01	0.06
22	<i>Selaginella myosurus</i> (SW.) Alston.	80	12	15	4.04	2.45	1.36	7.85	0.04	0.02	0.19
23	<i>Craterispermum cerrinanthum</i> Hiern.	40	2	5	2.02	0.41	0.45	2.88	0.02	0.01	0.13
24	<i>Carpoloba leutea</i> G.Don.	20	1	5	1.01	0.20	0.45	1.66	0.02	0.01	0.25
25	<i>Triumfetta cordifolia</i> A.Rich.	80	4	5	4.04	0.82	0.45	5.31	0.03	0.02	0.63
26	<i>Ipomoea involucrata</i> P. Beauv.	20	2	10	1.01	0.41	0.90	2.32	0.02	0.01	0.50
27	<i>Landolphia dulcis</i> (R. Br) Pichon	20	1	5	1.01	0.20	0.45	1.66	0.01	0.01	0.25
28	<i>Marattia fraxinea</i>	60	12	20	3.03	2.45	1.81	7.29	0.04	0.02	0.33
29	<i>Panicum maximum</i> Jacq	80	20	25	4.04	4.08	2.26	10.38	0.05	0.03	0.31
30	<i>Sida rhombifolia</i> Linn.	80	10	12.5	4.04	2.04	1.13	7.21	0.04	0.02	0.16
31	<i>Nephrolepis bisserata</i>	80	20	25	4.04	4.08	2.26	10.38	0.05	0.03	0.31
32	<i>Cleom rotidosperma</i> DC.	20	4	20	1.01	0.82	1.81	3.64	0.02	0.01	1.00
33	<i>Chromolaena odorata</i> (Linn) RM King & Robinson	60	16	26.7	3.03	3.26	2.41	8.70	0.04	0.02	0.45
34	<i>Aspilla africana</i> (Pers) CD Adams.	40	30	75	2.02	6.11	6.78	14.91	0.06	0.03	1.88
35	<i>Heterotis rotundifolia</i> (Sm.) Jac. Fel.	100	20	20	5.05	4.08	1.81	10.94	0.05	0.03	0.20
36	<i>Platostoma africanum</i> P. Beauv.	20	6	30	1.02	1.22	2.71	4.94	0.03	0.02	1.50
37	<i>Spillanthes filicaulis</i> (Schum & Thonn.) CD Adams	40	16	40	2.02	3.26	3.62	8.90	0.04	0.02	1.00
38	<i>Mariscus longbreateatus</i> Cherm.	20	4	20	1.02	0.82	1.81	3.64	0.02	0.01	1.00
39	<i>Mariscus flabelliformis</i> Kunth.	20	6	30	1.01	1.22	2.71	4.94	0.03	0.02	1.50
40	<i>Asystasia gagentica</i> (Linn.) T. Anders.	20	4	20	1.01	0.82	1.81	3.64	0.02	0.01	1.00
41	<i>Alternanthera sessilis</i> (Linn.) DC.	40	14	35	2.02	2.85	3.16	8.03	0.04	0.02	0.88
42	<i>Anchormanis giganteus</i> Engl.	20	1.6	8	1.01	0.33	0.72	2.06	0.01	0.01	0.40
43	<i>Mariscus alternifolius</i> Vahl.	60	14	23.3	3.03	2.85	2.11	7.99	0.04	0.02	0.39
44	<i>Perotis indica</i> (Linn.) O. Ktze	40	32	80	2.02	6.25	7.23	15.77	0.06	0.04	2.00
45	<i>Oplimenus baumanii</i> (Retz) P. Beauv.	60	36	60	3.03	7.34	5.42	15.79	0.06	0.04	1.00
46	<i>Diodia sermentosa</i>	60	10	16.7	3.03	2.04	1.51	6.58	0.03	0.02	0.28
47	<i>Triumfetta rhomboidea</i>	40	2	5	2.02	0.41	0.45	2.88	0.02	0.01	0.13
48	<i>Vernonia cineria</i>	20	4	20	2.02	0.82	1.81	3.64	0.02	0.01	1.00
49	<i>Mitracarpus scarba</i>	60	8	13.3	3.03	1.63	1.20	5.86	0.03	0.02	0.22
50	<i>Spermaccoci verticillata</i>	40	4	10	2.02	0.82	0.90	3.74	0.02	0.01	0.25
51	<i>Axonopus compressus</i>	80	40	50	4.04	8.15	4.52	16.71	0.07	0.04	0.63
52	<i>Emilia sonchifolia</i>	20	8	40	2.02	2.45	3.62	6.26	0.03	0.02	2.00
53	<i>Aframommum danielli</i>	40	6	15	2.02	0.41	1.36	4.60	0.03	0.02	0.38
54	<i>Triumfetta eriophlebia</i>	40	12	30	2.02	2.45	2.71	7.18	0.04	0.02	0.75
55	<i>Funtumia africana</i>	20	2	10	1.01	0.41	0.90	2.32	0.02	0.01	0.50
56	<i>Sida acuta</i>	40	12	30	2.02	2.45	2.71	7.18	0.04	0.020	0.75
57	<i>Digitaria horizontalis</i>	60	10	16.7	3.03	2.04	1.51	6.58	0.03	0.019	0.28
58	<i>Newbouldia laevis</i>	20	0.4	2	2.02	0.08	0.18	1.27	0.01	0.006	0.10
59	<i>Lagenaria guineensis</i>	60	6	10	3.03	1.22	0.90	5.15	0.03	0.016	1.67
		1980	490.6	1106.4				328.31			

## 4. Discussion

Floristic composition entails the individual species that occur in a stand or region. The nature of forest communities largely depends on the ecological characteristics in sites, species diversity and habitat status of species [40]. The study has shown that the area is richly endowed with floras of various strata and categories (trees, shrubs, herbs, lianers, and climbers). The greater abundance of herbaceous vascular species among the families is an indication of a secondary vegetation structure heterogeneous in nature. The heterogeneity of the study site vegetation is being attributed to a number of retrogressive processes such as the influence of human activities, the regeneration and floristic succession of study site. This has resulted to changes in vegetation structure in terms of abundance and species biodiversity. This corroborates the assertion by Cubizolle *et al.* [41] who observed human activity as an important agent influencing plant species biodiversity. Biodiversity has recently emerged as an issue of both scientific and political concern primarily because of an increase in extinction rates caused by human activities [42]. Several very large experiments have addressed the relationship between biodiversity, measured as species richness, and ecosystem function [43, 44, 45, 46, 47 48].

Ecological succession due to prevailing human factor and local environmental conditions such as hydrological dynamics has contributed to variation in floral diversity of the project site in terms of the emergence of heterogeneity under stable and moderate environmental factor. In general, plant community ecologists are concerned with patterns of species response to environmental gradients [49, 50, 51] and tend to adopt (if only implicitly) a continuum approach to vegetation with its assumption of continuous change in composition with position in the multi-dimensional environmental space [52]. The study site has shown differences in the ranks of species in terms of frequency, abundance, density, diversity, importance value index and distribution pattern in different transect. The decreased shift in vegetation composition in dry season may have also ensued from the loss of annual species that may not have been environmentally adapted to such a seasonal change due to decline in moisture content (dry habitat) of the site. However, other parameters like topography, soil, climate, aspect, altitude and geographical location do influence the vegetation diversity of forest.

Frequency is a measure of the uniformity of distribution of a species; thus a low frequency indicates that a species is either irregularly distributed or rare in a particular stand or forest. Frequent distribution of plant density, cover, biomass per unit area, and height, are used as a measures for expressing biological abundance and biological dominance of vegetation, have also been used to describe species composition and spatial patterns of vegetation in different plant communities [53]. High frequency indicated more frequent distribution of species at the TDU site due to optimum environmental conditions such as the moisture content from the prevailing rainfall during the wet season. Species dominant during the

different seasons at the site were *M. subulatus*, *A. macrophylla*, *A. obanensis*, *E. guineensis*, *H. madagascariensis*, *S. myosurus*, *L. macrophyllum*, *M. esculenta*, *P. pinnata*, *T. cordifolia*, *M. fraxinea*, *P. maximum*, *A. bussei*, *S. rhombifolia*, *S. garkaena*, *N. pumicicola*, *N. bisserata* and *H. rotundifolia* for wet season, whereas in dry season *H. rotundifolia* showed high dominance at the site. Their dominance in a particular season is seen due to the availability of optimum conditions for their growth. Similar observations in context with the present study were also reported by Kukshal *et al.* [54] and Shameem *et al.* [55]. Thus it becomes evident that during these seasons frequent occurrence of species is mainly due to the presence of enough moisture and micro-nutrients [56]. Difference in the species composition from site to site is mostly due to micro-environmental changes [57]

It is essential to consider the environmental (e.g. climatic) control over the niche dimensions of individual species and patterns of local species richness (alpha diversity) before attempting to develop general principles for diversity theory. Species diversity is one of the most important characteristics of a community; it is a mechanism which generates stability. The nature of plant community at a place is determined by other that grows and develops in such environment [58]. The herbaceous nature of the site could also be a reflection of its life form transition stage with low shrubby and tree status at the time of sampling following human and environmental influences and conditions. This is in conformity with Shameem *et al.* [55] who observed high diversity of herb layer in the absence of much vegetation cover. Though similar decreases in species abundance and diversity have been recorded among species, this possibly could be due to anthropogenic gradient such as the local devegetation for fuel. However, the ecosystem still maintains the status of abundance, richness and evenness.

Species richness is defined as the number of species (i.e. trees, shrubs, vascular plants) per unit area. There is growing interest in quantifying patterns of species richness in tropical forest especially in forest fragments in a landscape mosaic. Landscape ecologists have used landscape metrics to estimate tree species richness with relatively little success because these variables do not take into account levels of natural and anthropogenic disturbance and the successional status of forests [58, 60, 61]. Numerous problems regarding the study of species richness need to be clarified, including the role of disturbance [62], and the relative importance of biotic versus abiotic factors [63, 64]. Huston [62] reviewed species richness extensively, and regarded patterns of species richness as being determined by the interaction of disturbance with environmental gradients and competitive exclusion. Although over any large region, distribution of species richness is likely to be governed by two or more environmental gradients [65, 66], species richness studies in relation to environmental gradients have been mainly single-factor studies.

This assertion could be reaffirmed by a macro-scale study, which has attributed species diversity richness to be a product

of water energy dynamics [67]. Tropical studies have correlated the importance of moisture and related factors to species richness [68]. Similarly changes in the gradient of species richness pattern have also been commonly explained by factors such as climate productivity and other energy related factors [69]; while Lomolino [70] has pointed out that many components of climate and local environments such as temperature, precipitation, seasonality and disturbance regimes vary along species amplitudinal gradient which ultimately create variation in their richness. A re-analysis of data by Pausas and Austin [71] also suggests that environmental parameters (especially rainfall) may also be involved in determining species richness. This corroborates Currie [72] and O'Brien [73, 74]. Richerson & Lum [75] found a positive logarithmic relationship between Californian plant-species richness and rainfall, the environmental variable that accounted for the greatest variance in species richness in their study. Knight *et al.* [76] and O'Brien [73] found positive correlation between mean annual rainfall and woody species richness in southern Africa. Gentry [77] found an increase in neotropical plant species richness with precipitation up to about 4000mm where species richness reaches an asymptote; however, he also noted that there were differences that could be explained by seasonality of rainfall and soil nutrients.

Spatial variation might be due to the soil type and its composition, elevation of sites, moisture contents of soil, nature of disturbance, human interference and isolation of study site populated regions [78]. Maximum density in wet season was presented by *M. esculenta* and *A. compressus* showed highest density in dry season. In general, density of herbaceous species varied at both site. These changes are attributed to changes in microclimate among other factors. Similar changes were also reported by Ilorkar and Kharti [79]. Studies conducted by Abdullah *et al.* [80] mentioned climatic factors as a reason to influence the distribution of species in certain habitats. Species richness and frequency of occurrence is further supported by the fact that landscapes are never static, their elements are in permanent temporal and spatial flux [81, 82]. Comparatively, *O. corymbosa* and *A. africana* commonly showed maximum importance in wet season and *A. compressus* in dry season at the TDU site. However, this can be correlated with the assertion that the dominance of certain species during a particular period could be as the other co-dominant species do not reach maturity to complete their life cycle [55]. Also studies on analysis of vegetation have been carried out particularly in terms of phytosociology, species diversity, richness and abundance across different physiognomic unit in various parts of the world [83, 84-86, 87]. This agrees with the postulation that the tropical rainforest is normally made up of intricate mixture of plants belonging to different plant families, genera and species.

The TDU site when compared based on hydrological seasonal variation, species similarity index was observed to show similar vegetation complex in terms of species composition with a maximum similarity of 56% despite the difference in species richness and abundance due to seasonal

variation. During the wet season a high number of species occurred at the site, where as a declined trend was observed when the dry season approached resulting to dissimilarity (67%) among the tree species community structure. This is related to differences in micro-climatic conditions and anthropogenic impacts influencing growth of different species at the site. A high degree of different dissimilarity among species community has also been reported by Verms *et al.* [88]. A considerable similarity was depicted in the herbaceous and shrubby community structure with an index similarity of 56% and 62% respectively.

## 5. Potential and Associated Environmental Impacts and Mitigation Measures

### 5.1. Potential Impact

The Thermal Desorption Unit (TDU) is imminent of environmental perturbation as it may affect the environmental segments of the surrounding. This is often attributed to emission of large particulate matters and dangerous gases which disperse over long distance causing ailment and disorder to plant and other living organisms including inhabitants of surrounding communities. However, the direct and indirect impact may result to:

1. Possible deposition of suspended particulate matter (SPM) on the flora composition of the project site and surrounding communities.
2. Because of the deposition on plant the photosynthetic process will be very badly affected resulting to chlorosis and other associated physiological stress.
3. This could also become a barrier to the transport and translocation of materials from the leaf to various parts of the plant species.
4. These particles may also penetrate inside the plants through leaves and branches thereby creating imbalance and localization of minerals, micro and major nutrients in the plants. All these affect the plant growth very badly.
5. Possible continuous and long term deposition of SPM may also cause the fertile and forest land to be unproductive for plants and farming around the surrounding communities.
6. The vegetation composition and structure may also be affected due to corrosive reactions of acid rain and precipitation.
7. The effect of a new activity on the area causing disturbance and interference in the host communities way of life.
8. Loss of habitat of many species.
9. Damages and general loss of biodiversity.
10. Thermal pollution could cause direct thermal shocks, changes in dissolved oxygen and redistribution of organisms in the local community.
11. Some of the plants can be killed by sudden temperature changes that are beyond the tolerance limit of their metabolic systems.

## 5.2. Mitigation Measures

1. Fire outbreak in the area and surrounding vegetation shall be prevented.
2. Organizations shall institute a contingency plan (and should there be an existing one, need to be enforced effectively) which addresses the identification and protection of vulnerable and sensitive areas including the surrounding vegetation.
3. Vegetation clearing shall be minimized and limited to only required area (within the limit of the acquired land as this may influence negatively the existence of biodiversity of the area). Thus there is need for the creation and development of a buffer zone for flora that may have been displaced or lost their natural habitation as a result of such project.
4. Areas not directly used for the project should have the following mitigative measures viz.
  - Vegetation will not be cut back to bare soil and should be left to decay naturally.
  - Overhanging plant species will not be cut back
  - There should be no chopping or removal of plant species of any kind and care should be taken to avoid damage to root zones in project operations.
  - Branch removal may be necessary for the project site but this will be performed so as not to adversely affect the growth characteristics of the mangrove vegetation.
  - Exploitation of forest resources by both contractors and staff of organization shall be prohibited. The management shall provide employment for the host communities by ensuring that majority of the unskilled and semi-skilled labour needed for the project execution shall be obtained from the surrounding communities.
  - Routine inspection of project location and facilities shall be maintained to ensure facility integrity and guide against facility degeneration / collapse and pollutant release on vegetations of the area.
5. There is need for the management to institute an integrated conservation and development strategy considered as a valuable land use option to reconcile development and conservation objectives in rural areas for a profitable exploitation of resources by local residents.

The application of such a concept in communal lands outside protected areas has to meet two main requirements to ensure a sustainable implementation. First, it must rely on the support of local communities, through their active involvement in biodiversity management operations and hence decision making. Secondly, it requires precise and regular information on flora abundance and trends to ensure that management schemes are adaptive and allow for a sustainable use of biodiversity populations. Consequently, the implementation of a community-based conservation programme needs the development of a monitoring method that respects a compromise between its applicability by local communities, both in terms of finance and skills, and the reliability of results.

## 6. Conclusion

Understanding of vegetation structure and component of ecosystem is important in several environmental baseline and impact studies. Such investigation of vegetation is often carried out in order to establish the degree of imminent environmental hazard and recovery of such envisaged ecological hazard as could be the case with TDU Waste management project. In the event of uncontrolled and accidental discharge of SPM, a preconceived knowledge of the vegetation is helpful in the determination of long and short-term effects of such emission on all major ecological habitats of the affected area. It will also give adequate support and facilitate the identification and assessment of associated environmental problems such as socio-economic and health implications of ecological predicament that many arise as a result of the incident.

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