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RESEARCH ARTICLE

Floral composition and diversity of the lagos coastal environment, South-Western, Nigeria

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Abstract

The present study investigates the floral diversity of the Lagos coastal environments by sampling 21 points using the quadrat method. The study revealed two major aquatic ecosystem types (mangrove and freshwater swamp) and recorded 125 species belonging to 108 genera and 49 families. While *Alchornea cordifolia* and *Raphia hookeri* were found as the most frequent, *Acalypha crenata* and *Acrostichum aureum* were the least abundant species. The highest and lowest species-rich locations were Unilag ($n = 125$ species) and Abule Osun ($n = 2$ species), respectively. The vegetation structure of the LCE is dominated by herbaceous species. Our findings provide insights on the flora diversity of the LCE, and a guideline for the effective conservation of near-threatened species such as *Nauclea diderrichii* and *Mitragyna stipulosa* in this coastal ecosystem is presented.

KEYWORDS
Coastal zones, Lagos state, species distribution, vegetation types, β-diversity

Résumé

La présente étude porte sur la diversité florale des environnements côtiers de Lagos en échantillonnant 21 points selon la méthode du quadrat. Cette étude a révélé deux grands types d'écosystèmes aquatiques (mangrove et marais d'eau douce) et a permis d'enregistrer 125 espèces appartenant à 108 genres et 49 familles. Contrairement à Alchornea cordifolia et Raphia hookeri qui étaient les plus fréquentes, Acalypha crenata et Acrostichum aureum étaient les espèces les moins abondantes. Les endroits les plus riches en espèces et les moins riches étaient respectivement Unilag ($n = 125$ espèces) et Abule Osun ($n = 2$ espèces). Le couvert végétal du LCE est dominé par des espèces herbacées. Ces résultats donnent un aperçu de la diversité de la flore du LCE, et présentent une ligne directrice pour la conservation efficace des espèces quasi-menacées telles que Nauclea diderrichii et Mitragyna stipulosa dans cet écosystème côtier.

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1 | INTRODUCTION

The coastal zone is a narrow transition area that connects terrestrial and marine environments. Typically, it is one of the most productive and valued ecosystems characterised by highly diverse ecosystems such as coral reefs, beaches, dunes, mangroves, and wetlands (UNEP, 2006; Nagelkerken, 2009). More than 90% of the biological and non-biological resources of the world's biodiversity have been estimated to be concentrated around the coast (Ahove, 2001; Amosu et al., 2012). It has also been estimated that the coast harbours about 50% of the world's population (Kremer & Crossland, 2002), which has been predicted to increase to 75% by 2030 (Amosu et al., 2012). This figure, however, is expected to increase drastically owing to growth, migration, and preference for the coastal environment. Thus, implying that 3.5 billion people presently rely on the coastal ecosystem, its habitat, and resources (Odunuga et al., 2018). For instance, intact coastal vegetation buffers shores and retains sediments from the effects of erosive processes, such as tides, waves, and storms (Costanza et al., 1997; Dugan et al., 2011). A large human population lives and depends on the coastal resources for food, medicines, shelter, and income (Awosika et al., 2001; Costanza et al., 1997; Polidoro et al., 2010). Therefore, the consequences of human preference for coastal zones, causing rapid environmental change, are expected to trigger further modifications in the vegetation structures and compositions of the coastal zones (Hillebrand et al., 2018).

African coastal zones are *made up* of *narrow, low-lying coastal belts consisting* of *continental shelves* and *coasts* of *32 mainland countries* (Ogbonna et al., 2020). They are composed of a variety of ecosystems, including barrier/lagoons, deltas, mountains, wetlands, mangroves, coral reefs, and shelf zones (Wong et al., 2014). Early ecological studies broadly classified *African coastal zones* based on vegetation characteristics and associated plant genera into four types (White, 1983): forests (swamp and riparian)—for example, *Anthocleista* and *Symphonia*, grasslands— for example, *Brachiaria*, *Cyperus*, *Echinochloa* and *Typha*, halophyte—for example, *Najas*, *Juncus* and *Diplachne*, and mangrove—for example, *Avicennia*, *Laguncularia*, and *Rhizophora*. The Nigerian region is characterised by large expanse coastal zones with diverse species diversity. A previous demographic study estimated about 25% of the total population of Nigerians occupies the coastal zones (Odunuga et al., 2018), and the continuous increase would directly impact the biodiversity resources (Nigeria Biodiversity and Tropical Forestry Assessment, 2008). Nigeria has a coastline stretch of about 860 km and consists of barrier islands, sandy beaches, lagoons, estuaries, mud beaches, and creeks of the Niger Delta (Amosu et al., 2012). The Nigerian coastline is bordered in the East and West by the Cameroon and Republic of Benin, respectively. Therefore, evaluation of the species assemblages of Nigerian coastal communities could improve the understanding of the biodiversity status of the coastal ecosystem in some other parts of Africa, especially, these bordering nations.

The Lagos coastal zone (Figure 1) comprises barrier Islands of ca. 200 km from Benin/Nigeria border eastward to the western limit of transgressive mud beach and adjacent to the gulf of Guinea backed by the Badagry creek (Lagos) and Lekki Lagoon (Amosu et al., 2012).

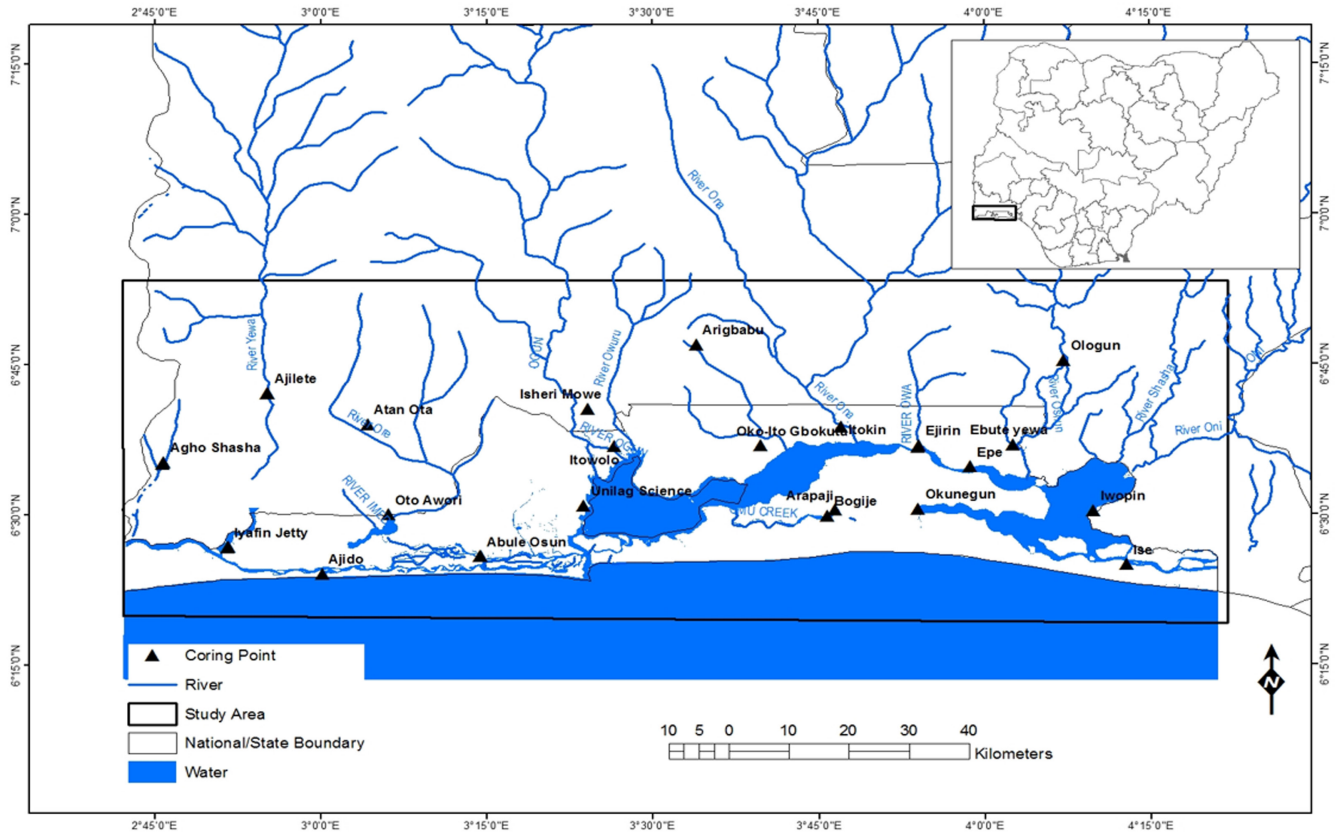


FIGURE 1 Map of the study area showing the 21 sampled points

The lagoons are generally shallow with depths between 1.5–3 m (Nkwoji et al., 2010). Lagos is characterised by a coastal environment with three broad vegetation types: Mangrove, Secondary Rain Forest, and Freshwater Swamp (Adeonipekun et al., 2019). Lagos, being the largest urban centre in Nigeria, has witnessed tremendous development due to the socio-economic status of the city (Wang & Maduako, 2018). The consequence of this growth has led to conspicuous spatial and temporal change in land cover and species diversity in this region (Adeola et al., 2004). For example, the conversion of the previously dense forest cover and water bodies in Ikorodu (part of Lagos) to other land use types caused the loss of vegetation and large expansion of grasslands (grasses, farmland, and sparse vegetation). It was further estimated that ca. 59.93% of the vegetal cover had been lost, and grassland has increased from 4.41 to 11.77% between 1984 and 2020 (Ubaekwe & Engwoh, 2020).

Previous ecological studies have provided insights into the species diversities of Lagos and some of its selected aquatic ecosystems (Adekanmbi & Ogundipe, 2009; Adeniyi et al., 2016; Adeonipekun et al., 2019; Ajikah et al., 2019; Ogunyebi et al., 2018; Oyebanji et al., 2020). These studies identified several plant species dominant on the Nigerian coast. Apart from the mangrove occupied by specific species, for example, *Rhizophora* spp., *Acrostichum aureum* Cav., Anales Ci. Nat. 4: 104 (1801), *Avicennia germinans* (L.) L. *Conocarpus erectus* L., *Laguncularia racemosa* (L) C.F.Gaertn. and *Nypa fruticans* Wurmb, other species (e.g., *Andropogon* spp, *Chromolaena odorata* (L.) R.M.King & H.Rob., *Cyperus javanicus* Houtt., and *Typha domingensis* Pers are found in equivalent wetland habitats. A handful of past studies have also revealed the extent of vegetation change and anthropogenic impacts on coastal communities of Lagos state (Adekanmbi et al., 2017; Adekanmbi & Alebiosu, 2017; Adeniyi et al., 2016; Ajikah et al., 2019; Orijemie & Sowunmi, 2014; Oyebanji et al., 2020; Sowunmi, 2004). The above studies failed to provide a detailed floristic inventory of the coastal areas of Lagos. Therefore, there is still more to explore about the species distribution along the expanse of the Lagos coastal environments (LCE). To fill this gap, a broad ecological sampling was conducted across the diverse habitats of the LCE with preference for areas that have not been previously sampled. With this approach, it would be possible to explore the gross species inventory of the study area and explore the temporal distribution based on presence and absence data. The lack of detailed vegetation baseline data of the LCE might underpin the failure rate of most restoration programs in the Nigerian wetlands. Therefore, the general objectives of this study were (i) to document the species composition across the broad range of habitats within the LCE, (ii) to investigate the species richness and distribution patterns, (iii) to explore the to explore the species life form to determine the natural succession and degradation in the LCE, and (iv) to assess the conservation status of the encountered species (based on IUCN 2021v1 criterion)—whether or not, there are species with conservation priorities. The findings could be helpful to policymakers in formulating active environmental guidelines for the conservation and management of the LCE.

2 | MATERIALS AND METHODS

2.1 | Study area

The study was carried out in 21 communities around the LCE (Figure 1), which is located within 3.1 to 3.4° E and 6.5 to 6.8° N, South-Western Nigeria. The study area is a typically tropical climate with alternating wet (April to July, August, and September) and dry (October to March) seasons. The estimated average temperature and rainfall are 27.2°C and 1461 mm, respectively (Oloruntola et al., 2019). The vegetation is characterised by the swamp forest of the coastal belt, which is a combination of mangrove forest and coastal vegetation developed under brackish conditions of the coastal areas and the swamp of the freshwater lagoons and estuaries.

The occupations of the people include trading, farming, and fishing. Other human activities in the area revolve around commercial activities, transportation, and sand mining. In terms of development, the area encompasses both characteristics of the urban and rural world. As urbanisation expands in the area in the last two decades, the green environment is being replaced by brown environment, placing pressures on the coastal environment (Odunuga et al., 2018).

2.2 | Data collection

We remotely and randomly established the communities around the LCE using ArcGIS software, followed by a ground-truthing reconnaissance survey to confirm the accessibility for sampling, proximities of the points, and species assemblage formation. We facilitated access to some of the sampling points using a paddled canoe. Thereafter, we established a total of 21 communities as sampling points, and the adjusted coordinates were recorded using a Garmin GPSMAP 64th Global Positioning System (GPS). The newly generated coordinate was integrated into the map of the study area—Abule Osun, Agho Shasha, Ajilete, Arigbabu, Ajido, Arapaji, Atan Ota, Ebute Yewa, Ejinrin, Epe, Itokin, Itowolo, Ise, Isheri Mowe, Iwopin, Oko Ito Gbokuta, Okunegun, Ologun, Oto Iwori, Unilag, and Yafin jetty (Figure 1; Table 1). In each sampling point, we marked out a large quadrat size of 50 × 20 m plot (0.1 ha), and then, it was further demarcated into three random blocks of 5 × 5 m (Olowokudejo & Oyebanji, 2016). This was to ease sampling and increase the opportunity of encountering all plant species during inventory. For security reasons and resource constraints, we performed a one-time survey, however with preference for transitional period between dry and wet seasons (ie between March and May). This was to increase the chance of sampling both the short-dry-spell tolerant species and wet-season early colonisers (Adeonipekun et al., 2019). The habitats associated with the LCE were characterised using species occupancy as previously reported (Adekanmbi & Ogundipe, 2009; Olowokudejo

TABLE 1 Ecological status of each location of Lagos Coastal Environment

S/No	Location	Elevation (m)	Vegetation type
1	Itowolo	13.0	Freshwater Swamp/secondary vegetation dominated *Cyperus* and *Paspalum*
2	Arigbabu	63.0	Freshwater swamp/secondary forest located few meters away from Gbodomo village
3	Oko Ito Gbokuta	36.0	Freshwater swamp/secondar forest to about 1 km away from River Ona
4	Itokin	8.0	Freshwater swamp/secondary vegetation along Ijede
5	Isheri Mowe	28.0	Freshwater Swamp/secondary vegetation
6	Ologun	74.0	Freshwater Swamp/secondary vegetation
7	Iwopin	12.0	Freshwater Swamp/secondary vegetation
8	Epe	9.0	Freshwater Swamp/secondary vegetation
9	Ejinrin	8.0	Freshwater Swamp/secondary vegetation
10	Ebute Yewa	7.0	Freshwater Swamp/secondary vegetation
11	Okunegun	10.0	Freshwater Swamp/secondary vegetation
12	Ise	10.0	Freshwater Swamp/secondary vegetation
13	Arapaji	11.0	Freshwater Swamp/secondary vegetation
14	Unilag (Sciences)	10.0	Freshwater Swamp/secondary vegetation
15	Ajilete	15.0	Freshwater swamp/secondary vegetation dominated by *Sacciolepis africana* while some parts are used for subsistence farming.
16	Agho Shasha	3.0	Freshwater swamp/ secondar vegetation dominated by palms and *Alocacia*.
17	Atan Ota	64.0	Freshwater swamp/ secondary vegetation dominated by *Alchornea cordifolia* and ferns
18	Yaffin jetty	11.0	Freshwater swamp/herbaceous vegetation dominated by *Tpha* and *Ceratopteris*.
19	Ajido	13.0	Freshwater swamp/herbaceous vegetation dominated by *Typha and Eichhornea crassipes* (free floating aquatic plant species)
20	Oto Iwori	8.0	Freshwater swamp/ Secondary vegetation
21	Abule Osun	8.0	Mangrove swamp dominated by *Rhizophora racemose*

& Oyebanji, 2016; Oyebanji et al., 2020). Vegetation assessment was made through careful visual observations of the populations of species at each point. While on-site identification was being carried out, representative species were collected and preserved following standard herbarium procedures (Hildreth et al., 2017). These samples were taken to the Herbarium of the Department of Botany, University of Lagos for further taxonomic identification and confirmation.

2.3 | Species identification and classification

Field botanical characters used for identification include flowers, fruits, leaves (types and arrangements), and slash exudates. Plants identification followed the guidelines of Hutchinson & Dalziel, 1954, 1958, 1963, 1968), Hutchinson et al., (1972), Akobundu and Agyakwa (1998), Keay (2011) and Ayodele and Yang (2012). In instances where on-site identification was not possible, the preserved plant specimens were compared with the dried samples in the *University of Lagos Herbarium* (LUH). Also, we maintained a genus-level identification in situations where species-level identification was not possible due to a lack of distinct morphological characters. The final scientific names and authorities followed the International Plant Name Index 2020 (www.ipni.org) while the family classification was written according to the Angiosperm Phylogeny Group [The Angiosperm Phylogeny Group (APG), 2016]. For this study, none of the plant species collected was deposited as herbarium voucher specimen.

2.4 | Data analysis

The occurrence of each species was used to compute species distribution. We used the presence and absence (in binary forms – 1 and 0, respectively) to compare species compositions across the 21 studied locations in the LCE—(1) to determine if there are any significant differences in species composition between different sites, we performed Analysis of Variance (ANOVA) at a probability level of 0.05 as implemented in Origin software (v 2021), (2) to evaluate beta diversity among the sampled ecosystems/communities, Cody beta diversity (β-diversity) index was estimated to compare the pairwise species diversity among the sampled locations (Bacaro & Ricotta, 2007; Ferrier et al., 2007; Patel & Trivedi, 2017; Ricotta & Marignani, 2007; Whittaker et al., 2007). Our choice of Cody beta diversity index was to investigate the diversity (homogenous and heterogenous) between the sampled sites/communities based on presence and absence unlike Shannon and Simpson index that are more informative when computed using species composition. Here, we measured Cody beta diversity between the sites following Caramujo and Boavida (2010). That is, the higher the Cody beta value, the higher the dissimilarities between the pair of the sampled sites. (3) To determine (dis)similarities among the sampled points and the species composition, we performed cluster analyses—Jaccard Coefficient similarity (JCs) using an unweighted pair-group average (UPGMA) algorithm at 1000 bootstrap values (BS) replicates. The species diversity analyses were conducted using PAlaeontological STatistics software (PAST v 2.17c, Hammer et al., 2001). To determine the morphological structure/canopy cover—which govern the function of the forest ecosystems, such as ecosystem resilience, and succession stage, (Yao et al., 2022) of the LCE, we adopted a typical life forms classification of a tropical forest (Agbagwa & Chimezie, 2011; Mueller-Dombois, 1972; Nsa et al., 2021). Then, the species were grouped based on their stem habit according to Ebigwai and Akomaye (2014)—(i) woody-stem (trees and shrubs) and (ii) weak-stem (climber/creeper, herbs, grass, and fern).

2.5 | Conservation status assessment

The conservation status of the species was classified as Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in The Wild (EW), and Extinct (EX) based on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2021).

3 | RESULTS

3.1 | Flora composition

Our study revealed two main ecosystems mangrove (4.8%) and freshwater swamp (most dominant; 95.2%) and recorded 125 plant species belonging to 108 genera and 49 families in the LCE (Figure 2a–c; Appendix Table S1). Of the 49 families, two families, Asteraceae (11 species) and Euphorbiaceae (10 species), were most dominant while multiple families are represented with one species. The genus *Ficus* had the highest number of species (n = 5 species) followed by *Ipomoea* (4 species), *Cyperus* (3 species) and *Phyllanthus Senna*, *Lonchocarpus*, *Musa*, *Ludwigia*, *Lygodium*, *Solanum*, and *Corchorus* with 2 species each while the remainder 82 genera are represented with only one species each.

Six life-form categories were recorded around the LCE but were mostly herbaceous: herbs (n = 36 species), trees (29 species), shrubs (24 species), climbers (17 species), sedges/grass (10 species), and ferns (9 species) (Figure 3). Our study revealed that the assemblage of species in the LCE was largely weak stem plants. However, *Dryopteris clintoniana* (D.C. Eaton) Dowell, *Centrosema pubescens* Benth., and *Lasimorpha senegalensis* Schott. were the most common weak species while *Raphia hookeri* G.Mann & H.Wendl., *Alchornea cordifolia* (Schumach). Müll.Arg., and *Anthocleista vogelii* Planch. were the most common woody stem species (Appendix Table S1).

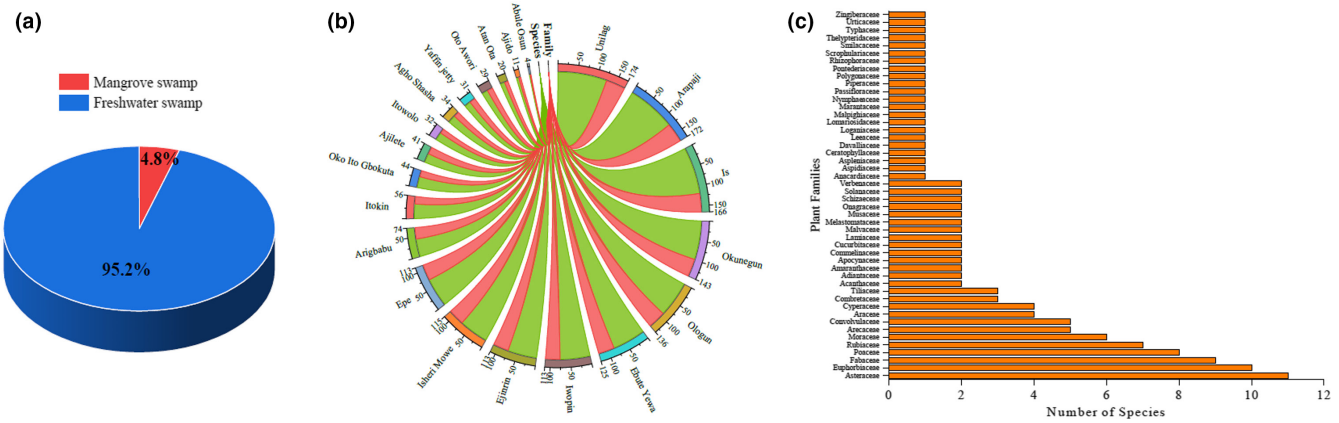


FIGURE 2 Habitat and vegetation characteristics of the Lagos coastal environments. (a) pie chart—the Vegetation types, (b) chord diagram—the distribution of species and families in each sampled point, and. (c) bar chart—distribution of species and families in the sampled points.

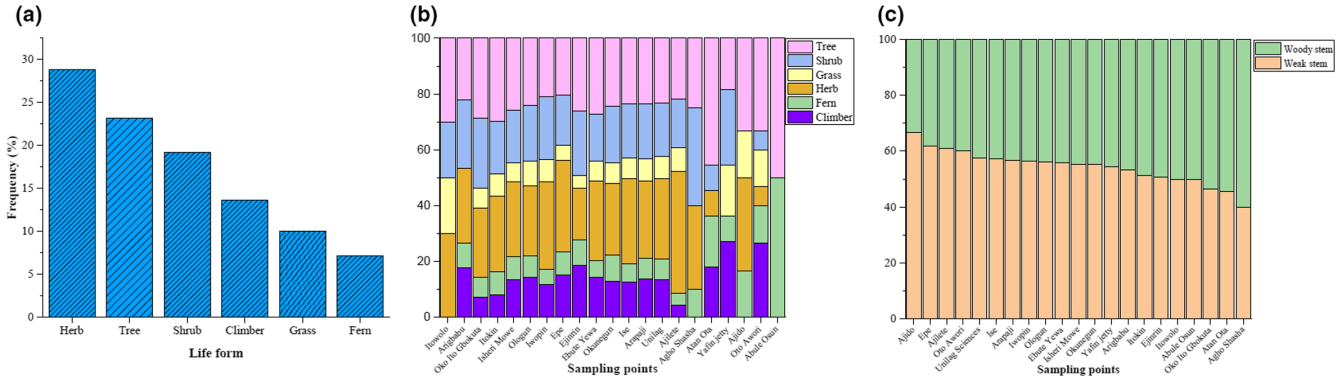


FIGURE 3 Comparative vegetation structure of the Lagos coastal environment based on the 21 sampled points. (a) total life form distribution, (b) distribution of life form per sample point, and. (c) distribution of stem formation per sample point.

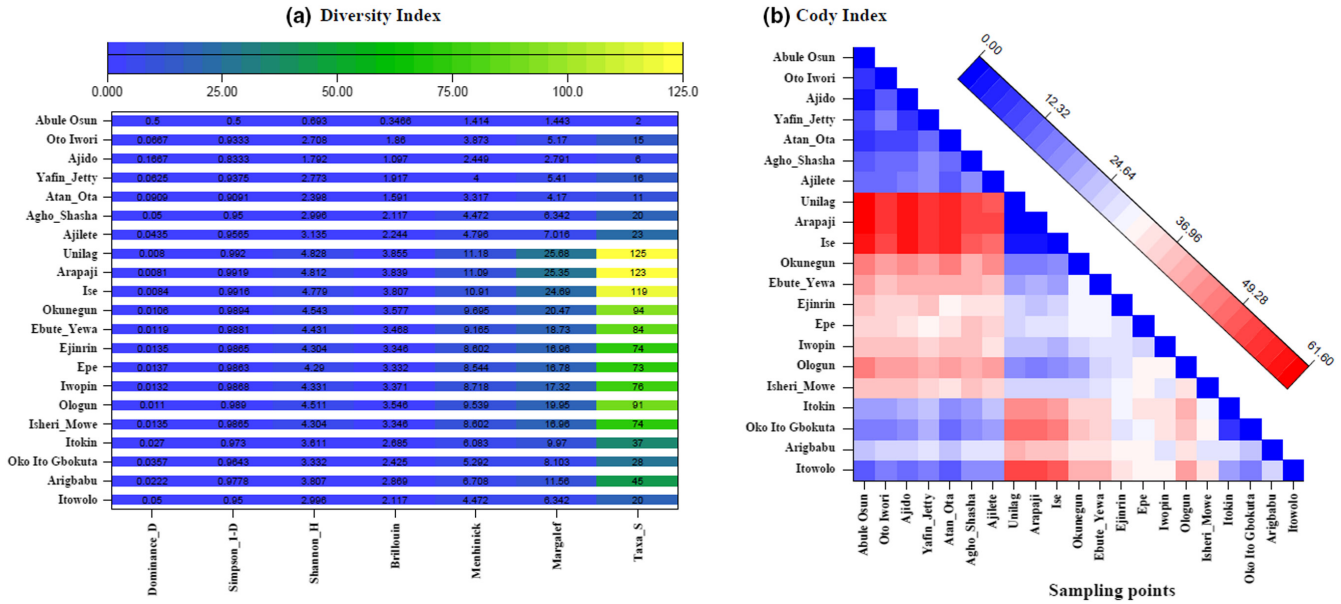


FIGURE 4 Heatmap showing the comparative species diversity analyses (β-diversity) of the LCE. (a) Diversity Index and. (b) Codex Index.

3.2 | Comparative species distribution of the LCE

3.2.1 | Species diversity

Species diversity and richness were recorded across all the examined locations in LCE (Figure 1; Appendix Table S1). Apart from Abule Osun, a typical mangrove ecosystem, the remaining sampling points were mosaic of freshwater, degraded forest, and patches of mangrove species. Comparatively, the highest species richness was recorded in Unilag (125 species and 49 families) followed by Arapaji (123 species and 49 families) and Ise (119 species and 47 species) and least in Abule Osun (n = 2 species) (Figure 1). We often encountered freshwater genera such as *Commelina*, *Costus*, *Ipomoea*, *Ludwigia*, and *Raphia* while the two mangrove genera (*Rhizophora* and *Acrostichum*) were common within the study area (Appendix Table S1). Our ecological survey showed independent overlapping species occurrence in all the sampled locations, as no species was restricted to a specific location (Appendix Table S1).

3.2.2 | Species indices

Our species diversity analyses based on presence and absence data revealed the heterogeneity in the plant composition of the LCE (Figure 4; Appendix Table S3). The ANOVA showed that there is no significant difference in the species diversity among the sampled points. The pair-wise β-diversity showed that species diversity differs between the paired plots (Figure 4; Appendix Table S3). The estimated global beta diversity was estimated (Cody = 403) while the β-diversity varies (low and high) between the multiple pairs of the locations ranging from 0.00 to 62. For instance, the β-diversity was high (≥59) between Unilag vs Abule Osun, Arapagi vs Abule Osun, and Ise vs Abule Osun. On the other hand, the β-diversity was low (1–4) between Unilag vs Arapaji, Unilag vs Ise, Ajido vs Abule Osun, and Arapaji vs Ise. The β-diversity pattern among all the pairs is presented in Appendix Table S3.

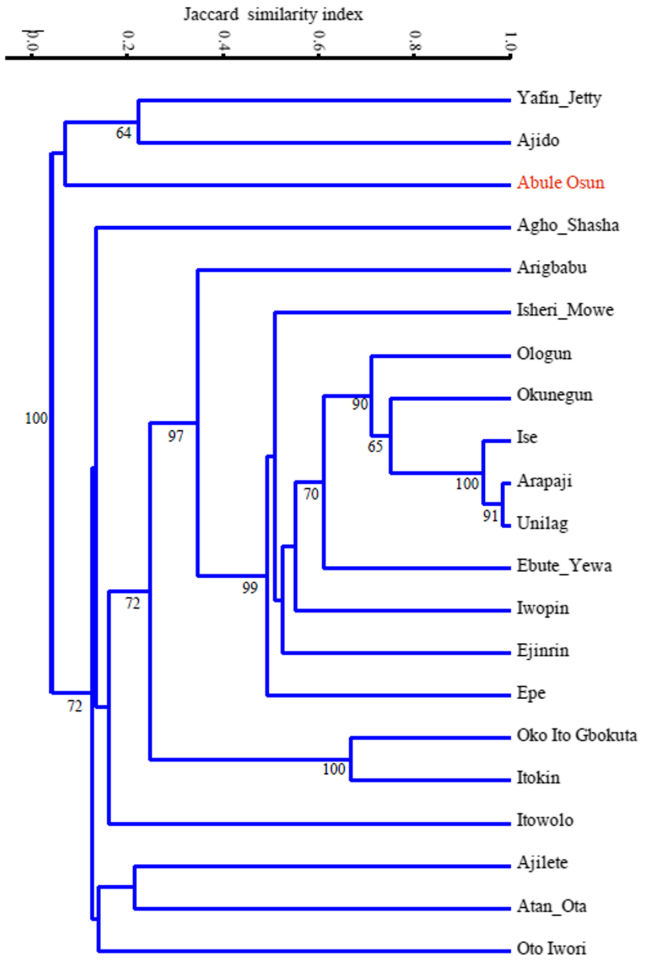


FIGURE 5 Cluster analysis—Similarity index of the sampled points based on paired group and species presence/absence. Location highlighted in red indicates the location with mangrove swamp. Only the *Bootstrap* values >50 were displayed along the branches

3.2.3 | Similarity index

The JCs similarity index ranged from weak (0.08) to strong (0.98) but highly supported two groups (BS = 100%): group 1 consisting of Abule Osun, Ajido and Yaffin Jetty (3 locations) and group 2 with the remaining 18 locations (Oto Iwori – Agho Shasha) (Figure 5). Also, our clustering analyses strongly supported the high similarity between the subgroup Unilag – Arapaji (JCs = 0.98; BS = 91%) + Ise (BS = 100%).

3.3 | Vegetation structure of the study area

Although the life forms are widely distributed across the study area, minute variations were observed among the sampled locations of the study area (Figure 2b; Appendix Tables S1 and S2). For instance, we could not record any species for one or multiple life-form categories for seven sample locations—Itowolo (climber and fern), Arigbabu (grass), Agho Shasha (grass and climber), Ata Ota (grass), Ajido (climber and shrub), Abule Osun (climber, grass, herb, and shrub), and Yaffin Jetty (herb). Multiple species formed the tree layer (≥ 10 m high), for example, *Anthocleista vogelii*, *Alstonia boonei* De Wild., *Artocarpus altilis* (Parkinson) Fosberg, *Cocos nucifera* L., *Elaeis guineensis* Jacq., *Gmelina arborea* Roxb. ex Sm., *Hura crepitans* L., *Raphia* spp, *Musanga cecropioides* R.Br. ex Tedlie, *Spondianthus preussii* Engl., *Terminalia catappa* DC., and *R. racemosa* reaching 10 m high. The shrubby layer was represented by *Alchornea cordifolia*, *Phyllanthus muellerianus* (Kuntze) Exell, *Psychotria nervosa* Sw., *Solanum erianthum* D.Don, and *Urena lobata* L.

3.4 | Conservation status of the species in the LCE

According to the IUCN red list assessment, one species [*Mangifera indica* Wall.], two species (*Nauclea diderrichii* Merr. and *Mitragyna stipulosa* Kuntze), 57 species and 65 species were Data Deficient (DD), Near Threatened (NT), Least Concern (LC) and Not Evaluated (NE), respectively.

4 | DISCUSSION

Our broad ecological sampling presents a detailed checklist of species diversity and ecosystem variations around the LCE, Nigeria. Thus, it adds to the existing knowledge and provides useful information towards the conservation of the habitats and their threatened species. Congruent with previous studies, we identified freshwater swamp and mangrove swamp forest in the LCE (Adekunle, 2006; Adeniyi et al., 2016; Adeonipekun et al., 2019; Ajikah et al., 2019; Obiefuna et al., 2013; Okorie, 2012; Olowokudejo & Oyebanji, 2016; Onyekwelu et al., 2008; Oyebanji et al., 2020). However, the total number of species recorded was lower compared to previous ecological survey of some selected coastal ecosystems in Southern Nigeria (Durugbo et al., 2012, 472 species; Olowokudejo & Oyebanji, 2016, 147 species). Although we documented similar species, our present study recorded a higher species richness compared to previous studies within the coastal areas of Lagos state (Adeniyi et al. (2016), 49 species; Ogunyebi et al. (2018), 67 species; Adeonipekun et al. (2019), 107 species; Oyebanji et al. (2020), 49 species). We therefore indicate the one-season sampling approach adopted in this study since we recorded higher species diversity. Nevertheless, we speculate the broad and seasonal sampling approach that included previously unsampled areas to explain the species distribution dynamics around the coastal ecosystems in the study area. Moreover, we attributed the lower number of species repeatedly documented in LGE to the persistent degradation of environmental conditions, which have caused rapid changes in the vegetation cover around the LCE. Previous studies have reported regular flooding, rapid urbanisation and industrialisation, unsustainable agricultural practices and tree cutting for firewood, local craft and fishing gears, which have caused rapid changes in the vegetation cover of the LCE (Adeniyi et al., 2016; Obiefuna et al., 2013; Ubaekwe & Engwoh, 2020). This may have predetermined the extant species diversity of the LCE compared to other similar ecosystems in Southern Nigeria. Comparatively, the total number of species recorded in our present study was markedly higher than records in Epe (e.g., Adeonipekun et al., 2019; $n = 52$ species). Lack

of information on the species richness in the remaining sample points limits deeper comparisons. Hence, our study provides a baseline and crucial information on species composition of plant communities in the LCE. We recommend a long-term survey of vegetation in the LCE. Overall, our results underscore the benefits of increased sampling for deep insights into the plant population dynamics of the LCE.

In line with previous studies (Kumar & Chelak, 2015; Elo et al., 2018; Oyebanji et al., 2020), we recorded core freshwater species such as *A. cordifolia*, *Costus afer* Ker Gawl., *Cyperus* spp., *L. senegalensis*, *Eichhornia crassipes* (Mart.) Solms, *Ludwigia* spp. L., *Pistia stratiotes* L., *Raphia* spp. and *Typha latifolia* G.Mey., and mangrove species, for example, *A. aureum* and *R. racemosa*. Also, we found the family Asteraceae dominant during this study, which agrees with previous studies (Ajikah et al., 2019; Nodza et al., 2021; Oni & Ndiribe, 2019). This is not surprising as the species from this family are seed-bearing herbaceous plants, excellent colonisers, wind-pollinated, flood-tolerant, and adapt to a wide range of environmental conditions (Torres & Galetto, 2011). We therefore attribute the dominance of Asteraceae species in LCE to some intrinsic drivers such as the high reproduction rates, efficient dispersal capacity, adaptation to climate change, and the ability to regenerate in the wetland environment, especially around flood plains and river valleys (Mphoweh et al., 2004).

The plant communities around the LCE are heterogeneous (Figure 4). The high species richness documented in Unilag, Arapaji, and Ise could be linked with the mosaic of habitats—mangrove, freshwater, and degraded secondary forest. This implies Unilag, Arapaji, and Ise are the biodiversity hotspot of the LCE. Moreover, the relatively high species richness in Unilag and Arapaji may result from deliberate conservation of the plant communities and entire biodiversity of the institution by the University management. In contrast, Abule-Osun had the least number of species because it represents a monotypic mangrove ecosystem. Typically, mangrove ecosystems have low plant species richness due to the extremely harsh conditions of the habitat (Asadi et al., 2018; Lee et al., 2017). Hence, species associated with this habitat often develop stilt roots and pneumatophores to absorb oxygen and survive anaerobic, salty, and muddy soil conditions (Krauss et al., 2003; Olowokudejo & Oyebanji, 2016). In the present study, two bioindicator species of the mangrove ecosystems were recorded (*A. aureum* and *R. racemosa*) and are included in the previously documented eight true West African mangrove species (Asuk et al., 2018; Ogar et al., 2016; Omogoriola et al., 2012; Oyebanji et al., 2020). These core mangrove species were found to form the vegetation cover of Abule Osun and other similar ecosystems within the study area. Therefore, the diversity disparities between the two identified habitats could be attributed to specific traits required to survive harsh ecological conditions instead of sampling size. On this note, we, therefore, recommend conscious conservation of this ecosystem which provides a mono-specific habitat in the LCE. Indeed, habitat type and preference are inseparably related to the distribution and diversity of plants observed in our current study.

Our ANOVA showed that there is no significant difference in the species composition of the sampled LCE. This is expected because the LCE mostly comprises freshwater and secondary forest; thus, it is inherently difficult to detect uncommon species within the studied locations. Our species indices analyses further provide shreds of evidence as most of the similar habitat clusters in the same clade (Figure 5). For example, the similarity index strongly supported the close relationships of locations Unilag + Arapaji + Ise. This suggests similar habitat conditions resulted in common species occurrence among these locations. Although our study failed to examine the factors that underpin the general distribution pattern of the species nevertheless, they are inextricably related to the sufficiency of seed dispersal by water, close proximity of the locations, similar elevation range, and largely uniform environments suitable for species establishment. In addition, the pairwise β-diversity inferred that species occupying similar or equivalent habitats may not necessarily be the same (Carvalho et al., 2013; Villéger et al., 2012; Wu et al., 2020). This uneven occurrence may be partly related to the prevailing flood regimes, microclimate, and the extent of anthropogenic activities in those areas. Therefore, the authors recommend that future studies should evaluate the role of water dispersal in shaping the plant community structure of the LCE.

The impact of human-induced stressors on forest canopy structure has been identified (Adeniyi et al., 2016). Similar to previous studies, the vegetation of the LCE is mostly herbaceous and dominated by the weak-stem species (57.6%) (Adekanmbi & Ogundipe, 2009; Adeniyi et al., 2016; Nodza et al., 2021; Oni & Ndiribe, 2019; Sanyaolu, 2015). The dominance of this life form category could be attributed to the adaptation to unfavourable ecological conditions, high proliferation, storage organs, efficient mechanisms for seed dispersal (Adeniyi et al., 2016), and exploitation of tree species by humans for several economic uses, for example, raffia palms (Mphoweh et al., 2004). In fact, the trees recorded around the LCE are mostly economically important species, for example, *A. altilis*, *C. nucifera*, *E. guineensis*, *G. arborea*, *Mangifera indica* Wall., *Musa* spp., *R. hookeri*, and *T. atappa*. Our study identified few locations—Agho Shasha, Atan Ota, and Oko Ito Gbokuta as locations rich in woody stem species. Given this fact, it could be inferred that the is a shift in vegetation structure and morphology of the Lagos coastal ecosystems (Figure 2; Table 1). Generally, all the studied sites are still undergoing degradation because of urbanisation, fishing, pollution, logging and agricultural practices. Thus, in agreement with Ebigwai and Akomaye (2014), the persistent interference of these habitat degradation indicators would continuously annihilate vegetation around the LCE. Such activities are, however, detrimental to the global ecosystem of the world. However, since these activities could not be absolutely abolished, we suggest enrichment planting of indigenous-woody species and a local biodiversity monitoring scheme to mitigate these activities and revive the natural vegetation to maintain the complex web of ecosystem and posterity. It is believed that the prevailing ecological conditions of the LCE, such as rainfall, humid tropical condition, and soil conditions (moisture content, nutrient content, and soil acidity), would support the rapid establishment of the reintroduced species (Ali et al., 2007). Future studies focusing on the modeling of the spatiotemporal dynamics of species distribution and habitat characterisation with time could yield insights into the (1) identification of the hotspot regions and

(2) potential role(s) of both (non)bioclimatic environmental variables around the LCE.

Our study showed that some species (57 species) encountered in the LCE were listed as LC, whereas the majority (65 species) have not been evaluated for their conservation statuses. Nonetheless, our study recorded two near-threatened freshwater species—*N. diderrichii* and *M. stipulosa* widely spread across our sample points except in Ajido, Abule Osun, Agho Shasha, Oto Iwori, and Yaffin jetty. Interestingly, these species are protected in Nigeria and also internationally by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (See the Schedules to the National Wildlife Species Protection Act: First Schedule—https://cites.org/sites/default/files/common/prog/niaps/Nigeria%20E-SC70-27-04-A25.pdf). Hence, the presence of these species implies that prompt conservation attention is required. Although widely spread in LCE, these species might be experiencing population reduction globally, influenced by limited distribution range and intense human exploitation (Adekunle et al., 2014). Therefore, the results of this study proposed regular biodiversity studies, monitoring, and conservation assessment of the vegetation of LCE to continuously ascertain the conservation status of these species and others not listed by IUCN Red List. This would be beneficial in ensuring the sustenance and long-term survival of the plant communities and their associated habitats in the LCE. Additionally, enlightenment campaigns should be conducted to sensitise the local population on the effect of unsustainable management and utilisation of coastal forests and their resources in the LCE.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript, and there is no financial interest to report. We certify that the submission is original work and is not under review at any other publication.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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