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An Assessment of the Biodiversity Status of Wetland Woody Flora in Bamenda III Sub Division, North West Region, Cameroon

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Abstract: *A study was carried out to determine the biodiversity status of woody plant species in wetlands in Bamenda III Sub Division, northwestern Cameroon, which are burdened by human activities of various forms. Three 10 m x 10 m plots separated by distances of 50 m were established along each of 9 line transects. Woody species within each plot were identified and their frequencies recorded for calculation of biodiversity indices. The biodiversity status of individual species was inferred from the values of Relative Density (RD). Thirty-one (31) species belonging to 27 genera and 19 families were encountered in the study area. Approximately forty-two percent (41.94 %) of the species were found to be "rare" (1.00 ≤ Relative Density ≤ 2.99) while 28.13 %, 19.35 %, and 6.45 % were "endangered"(0.00 < RD ≤1.00), "abundant" ((RD ≥ 5.00), and "occasional" (3.00 ≤ RD ≤ 3.99), respectively. Values of Shannon-Weiner index was 2.94 while that of Simpson index was 0.92. The results indicate that wetlands in Bamenda III Sub Division are characterized by a high species heterogeneity with rather low abundances of the individual species. The low numerical strength of the individual species may be attributed to the fact that the wetlands are disturbed as evident from the Margalef index of 1.95compounded by low plant regeneration potentials." with the following: "The low numerical strength of the individual species may be attributed to the fact that the wetlands are disturbed as evident from the Margalef index of 1.95, a situation that is further compounded by low plant regeneration potentials. The findings evoke a need for protection and restoration of the wetland ecosystems.*

1. INTRODUCTION

Wetlands are remarkably beneficial to mankind. According to the Millennium Ecosystem Assessment (2005), they offer several provisioning (e.g. fisheries support, peat production for fuel, timber and food production), regulating (e.g. water purification, flood control, carbon sequestration, and habitat for rare and endangered species), cultural (e.g. landscape aesthetics, relaxation sites, ecotourism, ecology education, and sustenance of cultures and religions), and supporting (e.g. soil development, primary productivity, chemical sources, sinks, and water storage) services. They also constitute an important reservoir for genetic materials, priding themselves among the world's cradles of biodiversity. Despite the numerous benefits, wetlands are severely threatened ecosystems worldwide (Liu *et al.*, 2020). In its 2021 Global Wetland Outlook report, the Convention of Wetlands revealed that as much as 35% of global wetland area has been lost since 1970.The loss of wetlands in Africa is overwhelming. In sub-Saharan Africa where wetlands constitute approximately 5-7% area coverage, nearly 50% of the original wetlands have been lost in the last five decades (Dube *et al.*, 2023).

Wetlands in Cameroon are the subject of degradation. They are typically of the two categories defined by Chiras (1991), namely; inland wetlands comprising fresh water streams, lakes, ponds, bogs, marshes, swamps, rivers and coastal wetlands including wet or flooded regions along the coastline such as mangrove swamps, salt marshes, bays and lagoons. The situation is alarming in Bamenda III Sub Division of the northwest region of the country wherein land wetlands are wantonly and indiscriminately destroyed due to pressure from an increase in population, housing and other infrastructural developments. The degradation of wetlands can have significant negative consequences on biodiversity, and regrettably so because the latter is the foundation of human survival and economic well-being (Bhat *et al.,* 2020). Biodiversity constitutes the resource base upon which the fate of future generations depend. Periodic assessment of biodiversity is crucial for making management decisions on maintaining the health of the ecosystem. The diversity of wetland provides different habitats that support different life forms. This study was aimed at investigating the biodiversity status of woody flora in swamps in Bamenda III Sub Division

2. MATERIALS AND METHODS

2.1. Description of Study Site

The study was carried out in Bamenda III, one of the three Sub Divisions that make up the Bamenda council area in Mezam Division, North West Region, Cameroon. Bamenda III Sub Division is located between latitude 6°15' and 6°25'N of the equator and longitude 10° 02' and 10°15'E of the Green which Meridian (Fig. 1). It is a gateway to and from Boyo, Ngoketunja, Bui and Donga Mantung Divisions. The Sub Division is bounded by Tubah Sub Divisional Council to the West, Bamenda I Sub-Divisional Council to the North, Bamenda II Sub-Divisional Council to the East and Bafut Sub Divisional Council to the South. With a total surface area of 67.9 km^2, the municipality is composed of two autonomous villages, namely Nkwen and Ndzah (Mbanga, 2018). Naturally, Bamenda III consists of the Ndzah plateau to the South East, the Nkwen escarpments which divided Ndzah from Nkwen, undulating and low lying terrain of Nkwen, and several waterfalls and streams dissecting the escarpment and low lying lands. The lowlands are the flooded plains that constitute the wetlands in Bamenda. The Bamenda III Council area shows great ecological variations with a Guinea-Savannah type climate that is characterized by two distinct seasons. The dry season runs from mid-November to mid-March to give way for the wet season which spans from mid-March to mid-November. Annual rainfall is between 2000 and 3000 mm and average annual temperature is 19.3 °C. The area is characterized by strong winds and a cover of heavy clouds that descend from the hills.

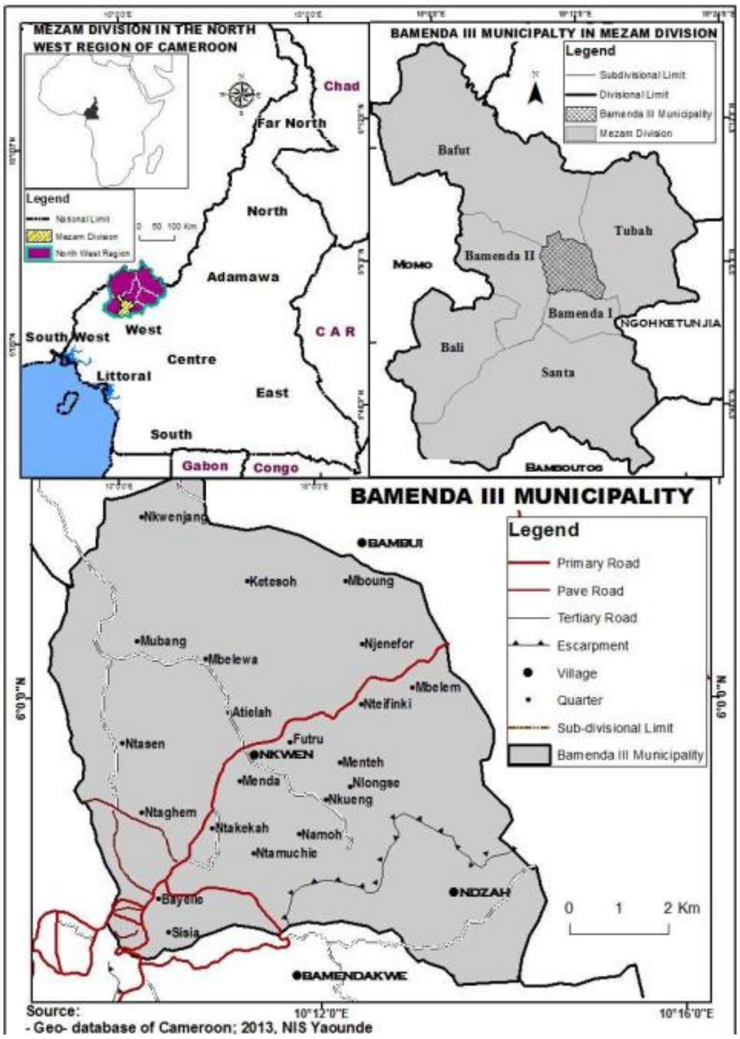

Fig1. *Location map of Bamenda III municipality in Mezam Division, North West Region, Cameroon*

2.2. Data Collection

Wetlands ecosystems were selected for data collection following a purposive sampling technique. This method was adopted to eliminate wetlands which were void of woody vegetation. A total of 9 line transects were established along which 3 plots each measuring 10 m x 10 m were laid out at distances of 50 m apart. Overall, there were 27 plots in the trial. Woody species within each plot were recorded alongside their frequency of occurrence. The botanical identification of the vegetation was based on expert knowledge and a plant identification apps. Those which could not be identified in the field were pressed in newspapers and conveyed to The University of Bamenda (6° 0' N, 10° 15' E) for proper identification. The triallasted from Aprilto June 2023.

2.3. Data Analysis

The following parameters were computed from the data:

$$RD = \frac{N_i}{N_T} \times 100 \quad (1)$$

Where *RD* = Relative Density of genus / species; N_s = number of individuals of genus / species*i*; N_T = total number of individuals of all genera / species (Mueller-Dombois and Ellenberge, 1974).

Following the protocol described in Ambebe *et al*. (2021), the biodiversity status of the various species was defined on the basis of their relative densities (RD) as follows:

- Abundant (RD ≥ 5.00)
- Frequent (4.00 ≤ RD ≤ 4.99)
- Occasional (3.00 ≤ RD ≤ 3.99)
- Rare (1.00 ≤ RD ≤ 2.99)
- Endangered (0.00 < RD ≤1.00)

$$d = \frac{(S-1)}{\ln N} \quad (2)$$

Where *d* = Margalef index (measure of species richness); S = total number of species; N = total number of individuals in the site; In = natural logarithm (Margalef, 1958). The value was then corrected algorithmically for determination of the ecological status of wetland as described in Hussain *et al*. (2012).

$$H = -\Sigma P_i \ln P_i \quad (3)$$

Where *H* = Shannon-Wiener index (measure of diversity within a site); P_i = proportion of individuals found in the species *i* ($\frac{RD}{100}$); In = natural logarithm (Shannon and Wiener, 1949).

$$D = 1 - \Sigma {P_i}^2 \quad (4)$$

Where *D* = Simpson index (a measure of diversity which takes into account the number of species present and the relative abundance of each species); P_i = proportion of individuals found in the species *i* (Simpson, 1949).

The method for rating biodiversity of wetlands developed by Hussain *et al*. (2012) was adopted for inferring the values of *H* and *d* (Table 1). On the other hand, *D* ranges from 0 to 1 where 0 indicates the absence of diversity and 1 indicates absolute diversity; values close to 1 show a community of many species with equally low abundances while those close to 0 express fewer species with one of them clearly dominant (Simpson, 1949).

Table1. *Ranges and values of diversity, richness and evenness for evaluating ecological indices of wetlands*

Shannon-Wiener index (0-5)		Margalef index (0-5)	
Range	**Status**	**Range**	**Status**
> 4 - 5	High	> 5	Integrated
> 3 - 4	Good	2.05 - 5	Semi disturbed
> 2 - 3	Moderate	< 2.05	Disturbed
> 1 - 2	Poor		
0 - 1	Bad		

Source: *Hussain et al. (2012)*

3. Results

3.1. Floristic Composition

The woody flora on wetlands in Mezam revealed 31 species belonging to 27 genera and 19 families. The dominant families with 3 genera each were Apocynaceae (11.1%)and Euphorbiaceae (11.1%). This was followed by Meliaceae, Myrtaceae, Rubiaceae and Sterculiaceae(7.4%) with two genera each. The remaining 15 families (3.7%) had just one representative genus. Generally, the RD of the species ranged from 13.3 to 3.3. All species identified were Angiosperms (Tables 2 and 3).

Table2. *Composition of wetlands woody flora in Bamenda III Sub Division*

S/N	Family	No. of genera	RD	No. of species	RD
1	Anacardiaceae	1	3.7037	1	3.33333
2	Annonaceae	1	3.7037	1	3.33333
3	Apocynaceae	3	11.1111	3	6.66667
4	Araliaceae	1	3.7037	1	3.33333
5	Asteraceae	1	3.7037	1	3.33333
6	Burseraceae	1	3.7037	1	3.33333
7	Clusiaceae	1	3.7037	1	3.33333
8	Euphorbiaceae	3	11.1111	3	10.0000
9	Fabaceae	1	3.7037	2	6.66667
10	Gentianaceae	1	3.7037	1	3.33333
11	Lamiaceae	1	3.7037	1	3.33333
12	Melastomataceae	1	3.7037	1	3.33333
13	Meliaceae	2	7.40741	2	6.66667
14	Moraceae	1	3.7037	4	13.3333
15	Myrtaceae	2	7.40741	2	6.66667
16	Phyllanthaceae	1	3.7037	1	3.33333
17	Rubiaceae	2	7.40741	2	6.66667
18	Sterculiaceae	2	7.40741	2	6.66667
19	Urticaceae	1	3.7037	1	3.33333
Total		**27**		**31**	

Table3. *Higher plant category of wetland woody flora in Bamenda III Sub Division*

S/N	Species	Family	Higher plant category
1	*Neoboutoniamacrocalyx*	Euphorbiaceae	Angiosperm
2	*Anthocleistagrandiflora*	Gentianaceae	Angiosperm
3	*Pseudospondiamicrocarpa*	Anacardiaceae	Angiosperm
4	*Leandrabalansae*	Melastomataceae	Angiosperm
5	*Psychotriasp*	Rubiaceae	Angiosperm
6	*Psidiumguajava*	Mrytaceae	Angiosperm
7	*Macaranga occidentalis*	Euphorbiaceae	Angiosperm
8	*Syzygiumpolyanthum*	Myrtaceae	Angiosperm
9	*Brideliamicrantha*	Phyllanthaceae	Angiosperm
10	*Albiziajulibrissin*	Fabaceae	Angiosperm
11	*Rauvolfiavomitoria*	Apocynaceae	Angiosperm
12	*Voacangaafricana*	Apocynaceae	Angiosperm
13	*Ficuslutea*	Moraceae	Angiosperm
14	*Vernoniaamygdalina*	Asteraceae	Angiosperm
15	*Canariumschweinfurthii*	Burseraceae	Angiosperm
16	*Acalyphadiversifolia*	Euphorbiaceae	Angiosperm
17	*Kola nitida*	Sterculiaceae	Angiosperm
18	*Vitexdoniana*	Lamiaceae	Angiosperm
19	*Albiziagrandiflora*	Fabaceae	Angiosperm
20	*Garcinia intermedia*	Clusiaceae	Angiosperm
21	*Ficusequatus*	Moraceae	Angiosperm
22	*Canthiumerarobusta*	Rubiaceae	Angiosperm
23	*Funtimiaafricana*	Apocynaceae	Angiosperm
24	*Ficusexasperata*	Moraceae	Angiosperm
25	*Polysciasfulva*	Araliaceae	Angiosperm

26	*Trichiliaamericana*	Meliaceae	Angiosperm
27	*Sterculiatragacantha*	Sterculiaceae	Angiosperm
28	*Annonasquamosa*	Annonaceae	Angiosperm
29	*Carapaguianensis*	Meliaceae	Angiosperm
30	*Ficus mucosa*	Moraceae	Angiosperm
31	*Boehmeriacaudata*	Urticaceae	Angiosperm

3.2. Biodiversity Status of Species

A majority (41.94 %) of the woody plant species wascategorized as "rare" (*Anthocleista grandiflora, Pseudospondia microcarpa, Psidium guajava, Syzygium polyanthum, Albizia julibrissin, Rauvolfia vomitoria, Canarium schweinfurthii, Vitex doniana, Albizia grandiflora, Ficus exasperate, Sterculia tragacantha, Carapa guianensis* and *Ficus mucosa*) (Table 4). Ranking second was the "endangered" category with 28.13 % of species comprising of *Ficuslutea, Polyscias fulva, Trichilia americana, Kola nitida, Garcinia intermedia, Ficusequates, Canthiume rarobusta, Boehmeria caudate* and *Annona squamosa. Neoboutonia macrocalyx, Leandra balansae, Psychotria sp, Macaranga occidentalis, Acalypha diversifolia* and *Vernonia amygdalina* were "abundant" with 19.35 %. While 6.45 % of species (*Bridelia micrantha* and *Funtimia africana*) was "occasional", only *Vocanga africana* (3.23 %) was "frequent" (Table 4).

When corrected for determination of ecological status, the value of Margalef index (*d*) was 1.95 inferring that the wetlands are disturbed (Table 1).The value of Shannon-Wiener index was indicative of a moderate diversity while that of Simpson's index was close to 1. The proportion of individuals per species (P_i) ranged from 0 to 0.17 (Table 4).

Table4. *Biodiversity indices and status of wetland woody flora*

S/N	Tree species	*RD*	*Pi*	*d*	*H*	*D*	Biodiversity status
1	*Neoboutoniamacrocalyx*	14.227642	0.142276	6.175832	0.277437	0.020243	Abundant
2	*Anthocleistagrandiflora*	2.439024	0.024390	0.908211	0.090575	0.000595	Rare
3	*Pseudospondiamicrocarpa*	2.845528	0.028455	1.089853	0.101284	0.00081	Rare
4	*Leandrabalansae*	6.910569	0.069106	2.906274	0.184659	0.004776	Abundant
5	*Psychotriasp*	17.073171	0.170732	7.447326	0.301796	0.029149	Abundant
6	*Psidiumguajava*	2.032520	0.020325	0.726568	0.079185	0.000413	Rare
7	*Macaranga occidentalis*	6.504065	0.065041	2.724632	0.177739	0.00423	Abundant
8	*Syzygiumpolyanthum*	1.626016	0.016260	0.544926	0.066976	0.000264	Rare
9	*Brideliamicrantha*	3.252033	0.032520	1.271495	0.111411	0.001058	Occasional
10	*Albiziajulibrissin*	2.845528	0.028455	1.089853	0.101284	0.00081	Rare
11	*Rauvolfiavomitoria*	2.845528	0.028455	1.089853	0.101284	0.00081	Rare
12	*Voacangaafricana*	4.471545	0.044715	1.816421	0.13895	0.001999	Frequent
13	*Ficuslutea*	0.813008	0.008130	0.181642	0.039123	6.61E-05	Endangered
14	*Vernoniaamygdalina*	6.910569	0.069106	2.906274	0.184659	0.004776	Abundant
15	*Canariumschweinfurthii*	1.219512	0.012195	0.363284	0.05374	0.000149	Rare
16	*Acalyphadiversifolia*	6.097561	0.060976	2.542989	0.170566	0.003718	Abundant
17	*Kola nitida*	0.813008	0.008130	0.181642	0.039123	6.61E-05	Endangered
18	*Vitexdoniana*	1.219512	0.012195	0.363284	0.05374	0.000149	Rare
19	*Albiziagrandiflora*	2.032520	0.020325	0.726568	0.079185	0.000413	Rare
20	*Garcinia intermedia*	0.406504	0.004065	0	0.022379	1.65E-05	Endangered
21	*Ficusequatus*	0.813008	0.008130	0.181642	0.039123	6.61E-05	Endangered
22	*Canthiumerarobusta*	0.813008	0.008130	0.181642	0.039123	6.61E-05	Endangered
23	*Funtimiaafricana*	3.252033	0.032520	1.271495	0.111411	0.001058	Occasional
24	*Ficusexasperata*	1.219512	0.012195	0.363284	0.05374	0.000149	Rare
25	*Polysciasfulva*	0.813008	0.008130	0.181642	0.039123	6.61E-05	Endangered
26	*Trichiliaamericana*	0.406504	0.004065	0	0.022379	1.65E-05	Endangered
27	*Sterculiatragacantha*	1.219512	0.012195	0.363284	0.05374	0.000149	Rare
28	*Annonasquamosa*	0.813008	0.008130	0.181642	0.039123	6.61E-05	Endangered
29	*Carapaguianensis*	1.219512	0.012195	0.363284	0.05374	0.000149	Rare
30	*Ficus mucosa*	2.032520	0.020325	0.726568	0.079185	0.000413	Rare
31	*Boehmeria caudate*	0.813008	0.008130	0.181642	0.039123	6.61E-05	Endangered
	Total	**100.000000**	**1**	**39.05305**	**2.944912**	**0.923227**	

4. DISCUSSION

As observed in this study, wetland plants are mainly angiosperms (Cronk and Fennessy, 2009). The high heterogeneity of species of several families and genera in wetlands in Bamenda III Sub Division as indicated by the Simpson index was expected as the ecosystems liein the tropical afromontane zone of Cameroon whose rich biodiversity is second only to that of Democratic Republic of Congo in Africa (Kumar *et al*., 2011, Takem-Mbi, 2013). However, the low abundances of the individual species could be attributed to the fact that the wetlands are disturbed as evident from the Margalef index. Additionally, the plants were found to have a low regeneration potential. As noted previously by Ballabha *et al*. (2013) and Malik *et al*. (2014), the disturbances are typically human induced. Wetlands in Bamenda III are heavily exploited for water, fish, firewood, palm wine, food, construction material, utility poles, sand, medicine, snails and other animals. In addition, they constitute a recreational swimming pool for children as well as a source of raw material for the local artisanal industry and land for crop and vegetable cultivation. Ngenwie (2017) has ranked resources in wetlands in Bamenda III Sub Division in order of intensity of exploitation. In a nutshell, the wetland ecosystems have increasingly come under pressure as a result of urban development which is mirrored in population growth, housing and other infrastructural developments.

Though numerically weak, more than a quarter of the species population is endangered. The presence of species like *Ficus lutea, Funtimia africana, Polyscias fulva,* and *Trichilia Americana* may be explained by two main points. Firstly, they are difficult to regenerate naturally due to difficulties in breaking seed dormancy, coupled with the flooded conditions of the natural wetland seed bed. Secondly, the trees are among the few species with good quality wood that is desirable for both fuel and local construction so that they are under threat of over-exploitation. This was evident on the study site from the presence of large number of tree stump residuals from felling. Indiscriminate felling of these species over the years has not only resulted in the reduction in their population but also their gene pool as old mature trees which could have been preserved as seed sources are unsustainably taken out of the biome. The finding of the present study is in accord with the works of Ibrahim *et al*. (2019) and Ambebe *et al*.(2021) in which substantial declines in species richness of disturbed forest patches was marked by anthropogenic activity which did not only reduce the floral cover but also resulted in the modification of micro-climatic conditions. When put together, the two most unfavourable categories on the scale of biodiversity accounted for up to 70 % of the species.

On the other hand, the finding that less than a fifth of the species was abundant is an indication that wetlands in Bamenda III Sub Division are in dire need of management strategies that have as primary objective the protection and restoration of the ecosystems (Pröpper *et al*., 2010).As evident from the obvious benefits, such a move is imperative for sustaining and upregulating the wide array of ecosystem services and functions inherent to the ecosystems. According to Kettenring and Tarsa (2020), employing strategic seed-based approaches in wetland restoration may be a first step to more quickly and completely recover the underlying vegetation structure and composition that supports these vital functions and services.

5. CONCLUSION

Although this study revealed a rich diversity of woody flora on wetlands in Bamenda III, abundances of the individual species was quite low. In fact, some species in the ecosystems are endangered. At the current rate of exploitation and utilization, the sustainability of wetlands in the study area is not guaranteed. Thus, the findings of this research evoke a need for protection and restoration of the ecosystems for an uninterrupted supply of its associated benefits to inhabitants of the municipality and beyond.

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