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Analysis of Regeneration Potential of Human-Disturbed Wetlands Woody Flora in Bamenda III Sub Division, North West Region, Cameroon

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ABSTRACT

Wetlands of the Bamenda III Sub Division in northwestern Cameroon are wantonly and indiscriminately destroyed by a rapidly growing human population to the advantage of infrastructural development and economic gain. Biodiversity of the ecosystems is threatened by the accompanying human activities. This study assessed the regeneration potential of the wetlands woody flora in the Bamenda III municipality. Three 10 m × 10 m quadrats were established at distances of 50 m along nine lines transects. Woody plant species were identified from each quadrat and the diameter at breast height (DBH) of all individuals per species was measured. The regeneration status of each species was determined by comparing its number of mature trees (DBH) > 10 cm), saplings (10 cm > DBH > 2.5 cm) and seedlings (DBH < 2.5 cm). Of 31 species encountered in the study area, only 01 (Bridelia micrantha) had a good regeneration potential. In contrast, regeneration was poor for 03 *Canarium schweinfurthii*, *Funtimia africana*, *Ficus mucosa*) and fair for 02 (*Pseudospondia microcarpa*, *Ficus lutea*) species. The regeneration status of the remaining 25 species (*Neoboutonia macrocalyx*, *Anthocleista grandiflora*, *Leandra balansae*, *Psychotria* sp., *Psidium guajava*, *Macaranga occidentalis*, *Syzygium polyanthum*, *Albizia julibrissin*, *Rauvolfia vomitoria*, *Voacanga africana*, *Vernonia amygdalina*, *Acalypha diversifolia*, *Kola nitida*, *Vitex doniana*. *Albizia grandiflora*, *Garcinia intermedia*, *Ficus equates*, *Canthiumera robusta*, *Ficus exasperata*, *Polyscias fulva*, *Trichilia Americana*, *Sterculia tragacantha*, *Annona squamosal*, *Carapa guianensis*, *Boehmeria caudata*) was new. The findings of this study highlight a need for restoration and protection of wetland ecosystems in the Bamenda III municipality.

Keywords: Anthropogenic Disturbance, Bamenda III Municipality, Biodiversity Loss, Wetland Degradation, Regeneration Potential, Woody Flora

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INTRODUCTION

Although they cover only around 6% of global land surface, wetlands are among the richest natural ecosystems in biodiversity. About 40% of the world's plant and animal species live or breed on wetlands (IPBES, 2019). Over 100,000 species have been identified in the world's freshwater wetlands alone, and the number keeps increasing each year (Greenpeace, 2023). The ecosystems are home to many threatened amphibians, reptiles, birds, and nurture thousands of plant species some of which are endemic and not found elsewhere in the planet. The contribution of wetland biodiversity to the healthy functioning of the earth is enormous. For instance, swamp vegetation filters pollutants from hitherto drinking water; peatlands constitute a vast reservoir of stored carbon, which helps in climate regulation; lakes and rivers are important suppliers of food and medicine; mangroves and seagrass reduce the intensity of storms and droughts; and canopies of large trees that act as windbreaks also remove particulate matter from the air, purifying it. More than a billion people across the world, i.e. ca one in eight, depend on wetlands for livelihood (Greenpeace, 2023).The worth of ecosystem services provided by wetlands exceeds that from forests, deserts or grasslands (Convention on Wetlands, 2018).

In spite of their important role in fostering human wellbeing, wetlands are declining at an alarming rate due to human activities and climate change. More than 50% of wetland areas were lost during the 20th century (MEA (Millennium Ecosystem Assessment), 2005) and over 33% has already been lost in the first two decades of 21st century (Hu et al. 2017). Overall, they have experienced a worrisome 35% loss globally since 1970 (Convention on Wetlands, 2021). Disappearing three times faster than forests, wetlands are the Earth's most threatened ecosystem. The contribution of human activities, directly or otherwise, to wetlands degradation is overwhelming. Widespread land development and clearing have caused increased erosion in upland areas leading to an increased sedimentation in lowlands with the outcome that the chemical and hydrologic regime of wetlands are modified. In addition, stream channelization; construction of hydroelectric dams; introduction of invasive species; pollution from industrial, municipal wastes, and runoff from agricultural fields have caused significant changes in the structure, function and quality of many of the ecosystems (Mitsch and Gosselink, 1993). The human interferences and climate induced alteration of wetland conditions constitute a threat to biodiversity.

In the Bamenda municipality of the North West Region of Cameroon, wetlands have been traditionally used for hunting, fishing, harvesting of timber and non-timber forest products, livestock rearing, and spiritual wellbeing. Historically, the extent and mode of exploitation kept the human impact on the ecosystems at a benign level. In Bamenda III, one of the three constituent Sub Divisions of Bamenda, which is experiencing the highest and an unprecedented rate of population growth and urbanization, an intensification of cattle rearing and harvesting of plants have compromised water quality and the habitat function of a majority of wetlands. Moreover, climate induced changes in the wetlands are accentuated by human interferences, like the planting of eucalyptus and market gardening crops, for short term economic gain. The ecosystems have become the subject of pollution from fertilizer and pesticide residues, household refuse, and car wash business operations. Observable trends in the structure, quality and area coverage of wetlands in Bamenda III Sub Division have warranted their conservation. The finding of Tanwie et al. (2024) that 41.94 % of woody flora in wetlands in Bamenda III is rare and 28.13 % are endangered further necessitates the latter contentment. In this study, we assessed the regeneration potential of the woody plants in an effort to determine the natural restoration capacity of the ecosystems.

MATERIALS AND METHODS

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. The Sub Division is a gateway to and from Boyo, Ngoketunja, Bui and Donga Mantung Divisions. It is bounded by Tubah Sub Division to the West, Bamenda I Sub-Division to the North, Bamenda II Sub-Division to the East and Bafut Sub Division to the South (Figure 1). With a total surface area of 67.9 km2, 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.

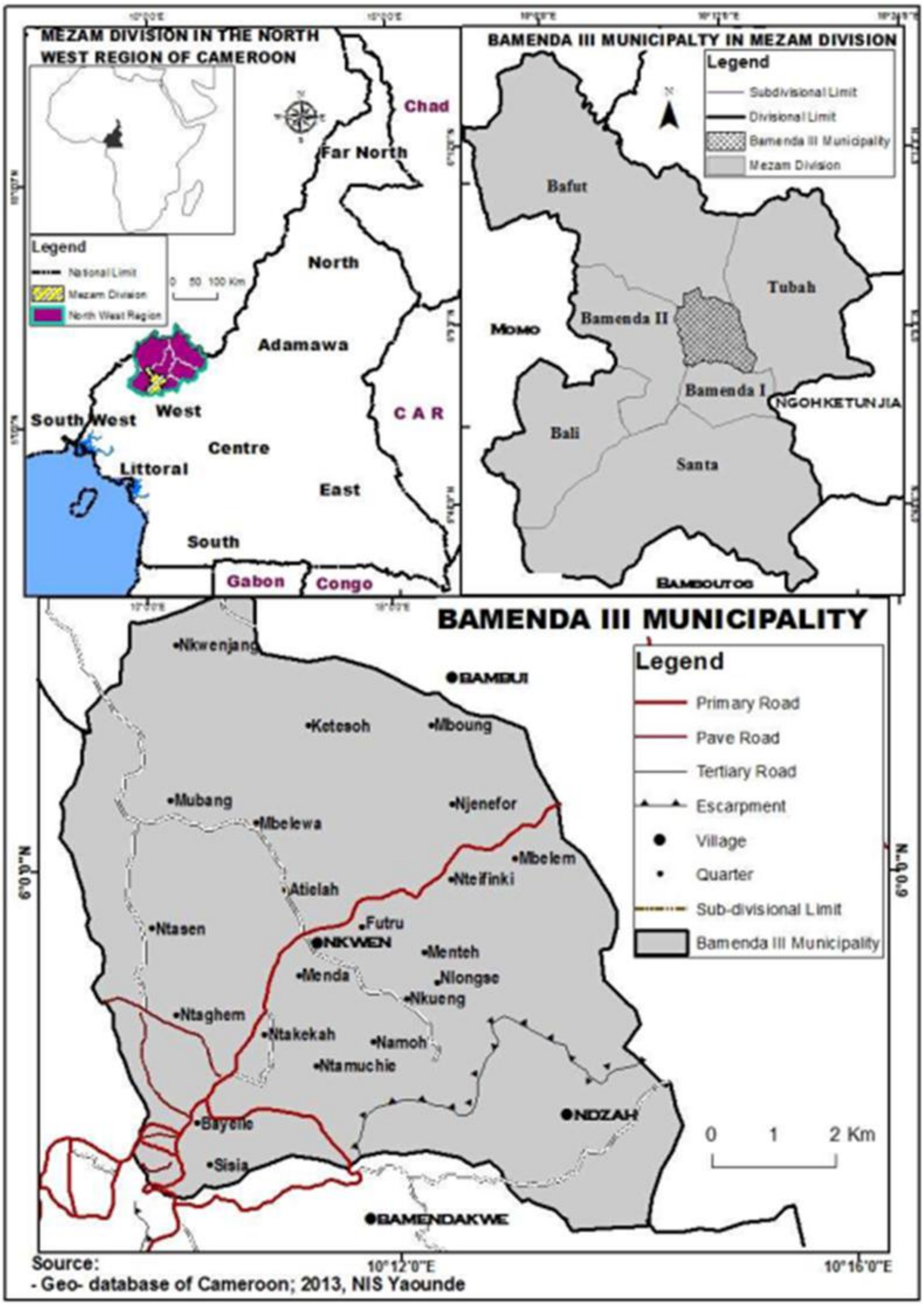

Fig. 1. Location map of Bamenda III municipality in Mezam Division, North West Region, Cameroon

Experimental design

Nine line transects were established in forested wetlands found in the research area. Three quadrats measuring 10 m × 10 m were demarcated at distances of 50 m apart along each of the transects. The geographical coordinates of each of the 27 quadrats in the trial was determined with a Garmin etrex C GPS meter (Table 1).

Data collection

Woody species within each quadrat were identified based on expert knowledge and plant identification apps. Those which could not be identified in the field were pressed in newspapers and conveyed to the Applied Botany Laboratory of The University of Bamenda (6° 0' N, 10° 15' E) for proper identification. The diameter at breast height (DBH) of each individual plant per species was measured with either a calibrated diameter tape or vernier caliper. Those with diameter at breast height (DBH) > 10 cm were classified as trees while those with 10 cm > DBH > 2.5 cm and DBH < 2.5 cm were placed under the category of saplings and seedlings, respectively, and their frequencies recorded with respect to the species (Dibaba et al. 2014; Gebrehiwot and Hundera, 2014; Bogale et al. 2017). The study lasted from April to June 2023.

Table 1: Geographical coordinates of quadrats

Transect/plot	Latitude	Longitude
T1Q1	$5^0$59’27.01824	$10^0$10’17.46012
T1Q2	$5^0$59’28.24548	$10^0$10’17.97132
T1Q3	$5^0$59’29.33232	$10^0$10’19.68816
T2Q1	$5^0$59’9.46824	$10^0$10’31.45152
T2Q2	$5^0$59’26.2302	$10^0$1031.45152
T2Q3	$5^0$59’28.2048	$10^0$10’21.73226
T3Q1	$5^0$59’7.33272	$10^0$10’24.18312
T3Q2	$5^0$59’24.72144	$10^0$10’25.43952
T3Q3	$5^0$59’9.46824	$10^0$10’47.84052
T4Q1	$5^0$59’37.26528	$10^0$10’24.54996
T4Q2	$5^0$59’39.40836	$10^0$10’24.55932
T4Q3	$5^0$59’40.75764	$10^0$10’24.95928
T5Q1	$6^0$0’12.63888	$10^0$12’4.06584
T5Q2	$6^0$0’13.81896	$10^0$12’6.1704
T5Q3	$6^0$0’15.05448	$10^0$12’4.75344
T6Q1	6^0O’31.3488	$10^0$12’7.29612
T6Q2	$6^0$0’15.83892	$10^0$12’8.91684
T6Q3	$6^0$0’15.92928	$10^0$12’11.00916
T7Q1	$6^0$0’17.06652	$10^0$12’13.581
T7Q2	$6^0$19.39032	$10^0$12’12.74184
T7Q3	$6^0$0’22.88916	$10^0$12’1236.2880
T8Q1	$6^0$0’22.83588	$10^0$12’12.05884
T8Q2	$6^0$0’27.50652	$10^0$12’14.094
T8Q3	$6^0$0’2930508	$10^0$12’143136
T9Q1	$6^0$0’29.97396	$10^0$12’13.45536
T9Q2	$6^0$0’32.43312	$10^0$12’13.54356
T9Q3	$6^0$0’30.9822	$10^0$12’12.7224

T = Transect; Q = Quadrat

Data Analysis

The regeneration status of the wetland and individual tree species was determined by comparing the population size of seedlings, saplings and mature trees (Dhaulkhandi et al. 2008; Tiwari et al. 2010; Gebrehiwot and Hundera, 2014; Deressa et al. 2023) and defining them as per the following categories:

- “Good” regeneration, if seedling > sapling > mature tree;
- “Fair” regeneration, if seedling < sapling > mature tree;

- "Poor" regeneration, if a species survives only in the sapling stage, but not as seedlings (even though saplings may be less than, more than, or equal to mature);
- "New", if a species has no mature, but only sapling and/or seedling stages

RESULTS

Uses of wetland woody flora in Bamenda III Sub Division

Trees identified had plethora of uses. Most of the species were medicinal with plant parts like leaves, roots and bark used to make decoctions for the treatment of tropical illnesses like malaria and typhoid (*Neoboutonia macrocalyx*, *Anthocleista grandiflora*, *Rauvolfia vomitoria*) and nervous system disorders (*Pseudospondia microcarpa*, *Voacanga africana*) (Table 2). Some species produce edible fruits and seeds which are common among the diets of the local people (*Psidium guajava*, *Canarium schweinfurthii*, *Garcinia intermedia*). Some have anti-microbial and antioxidant properties (*Macaranga occidentalis*, *Syzygium polyanthum*, *Ficus lutea*, *Ficus exasperata*), while others serve as a source of wood for furniture and construction (*Canarium schweinfurthii*, *Funtimia africana*, *Vitex doniana*).

Table 2: Woody plants and uses

S/N	Species	Family	Use
1	*Neoboutonia macrocalyx*	Euphorbiaceae	Leaves to treatment of malaria bark to treat worms, abdominal pains
2	*Anthocleista grandiflora*	Gentianaceae	Treatment of diabetes, hypertension, malaria, typhoid fever
3	*Pseudospondia microcarpa*	Anacardiaceae	Sedative and for treatment of general central nervous system disorders.
4	*Leandra balansae*	Melastomataceae	
5	*Psychotria* sp.	Rubiaceae	
6	*Psidium guajava*	Mrytaceae	Fruit is rich in vitamins A, C, iron, phosphorus and calcium and minerals. Treatment of diarrhea, dysentery, gastroenteritis, hypertension, diabetes, caries and pain relief and for improvement in locomotors coordination.
7	*Macaranga occidentalis*	Euphorbiaceae	Has antimicrobial activity, stomach wash for pregnant women.
8	*Syzygium polyanthum*	Myrtaceae	Has antibacterial and cytotoxic properties, used to treat diarrhea, rheumatism, and diabetes.
9	*Bridelia micrantha*	Phyllanthaceae	The bark is used to treat burns, wounds, venereal diseases, tapeworm, diarrhea and toothache. Leaf sap is used to treat sore eyes. Root is used to treat stomach pains, possibly gastric ulcers, or can be powdered and mixed with fat or oil and rubbed into the head to cure headaches.
10	*Albizia julibrissin*	Fabaceae	It is used for anxiety, cancer, insomnia, skin infections, and other conditions
11	*Rauvolfia vomitoria*	Apocynaceae	A decoction or extract of the roots is used for diarrhea, jaundice, venereal disease, rheumatism, snake-bites, colic, fever, to calm people with anxiety or epilepsy, and to lower blood pressure.
12	*Voacanga africana*	Apocynaceae	Extracts from the plant are also used in the

			production of vinpocetine, a medication used to treat Alzheimer's disease, and vinblastine, used to treat leukemia.
13	*Ficus lutea*	Moraceae	Has antibacterial activity and antidiabetic activity.
14	*Vernonia amygdalina*	Asteraceae	It is effective against amoebic dysentery, gastrointestinal disorders, and has antimicrobial and antiparasitic activities
15	*Canarium schweinfurthii*	Burseraceae	A bark decoction is used against dysentery, gonorrhea, cough, chest pains, pulmonary affections, stomach complaints, food poisoning as well as a purgative and an emetic; the resin is used against roundworm infections and other intestinal parasites; it has action on skin infections and eczema.
16	*Acalypha diversifolia*	Euphorbiaceae	It is used as animal food and a medicine
17	*Kola nitida*	Sterculiaceae	Cola fruits are used as tonics, stimulants and concoction for the treatment of fever, dysentery and exhaustion.
18	*Vitex doniana*	Lamiaceae	The fruit is used to improve fertility and to treat anaemia, jaundice, leprosy and dysentery. The root is used for treating gonorrhoea, and women drink a decoction of it for backaches
19	*Albizia grandiflora*	Fabaceae	Albizia species have been used in folk medicine for the treatment of cough, diarrhoea, insomnia, irritability, rheumatism, stomach ache, tuberculosis, and wounds .
20	*Garcinia intermedia*	Clusiaceae	Fruit is edible with an appealing sweet and sour taste. - Fruit can be used for making jams, jellies, and drinks.
21	*Ficus equates*	Moraceae	Considered to be critically important components of tropical ecosystems, may be particularly attractive to seed dispersers in that they produce large and nutritionally rewarding fruit crops.
22	*Canthiumera robusta*	Rubiaceae	Used as an ornamental plant in gardens and as a ground cover. It is also used as a medicinal plant to treat various ailments such as fever, headache, and skin diseases.
23	*Funtimia africana*	Apocynaceae	Latex used as an ingredient for arrow poison. Wood is used to produce furniture.
24	*Ficus exasperate*	Moraceae	It has been reported to possess antibacterial, anti-inflammatory, antioxidant, and antipyretic effects. The extract can, therefore, be effectively used in the treatment of wounds.
25	*Polyscias fulva*	Araliaceae	Bark maceration is applied as drops to the nostrils to treat mental illness. In Cameroon the bark is used in mixtures with other plants to treat epilepsy.
26	*Trichilia Americana*	Meliaceae	Used as a medicinal plant, as a source of timber, and as an ornamental plant in gardens
27	*Sterculia tragacantha*	Sterculiaceae	Used in the western part of Nigeria, for managing diabetes mellitus.

28	*Annona squamosa*	Annonaceae	Possesses a high pharmaceutical potential for treating cardiac ailments, thyroid-related disorders, diabetes, and cancer
29	*Carapaguianensis*	Meliaceae	Indigenous people have used it as insect repellent and in the treatment of various diseases.
30	*Ficus mucosa*	Moraceae	Have laxative properties and are used to treat constipation and digestive issues.
31	*Boehmeria caudate*	Urticaceae	They are applied externally to treat haemorrhoids, and are made into a lotion to treat eye problems

Regeneration status of wetlands and woody flora

The majority of plants in the study area were saplings while the least represented were of the mature tree stage (Figure 2). The regeneration status of wetlands in Bamenda III Sub Division was therefore inferred to be fair.

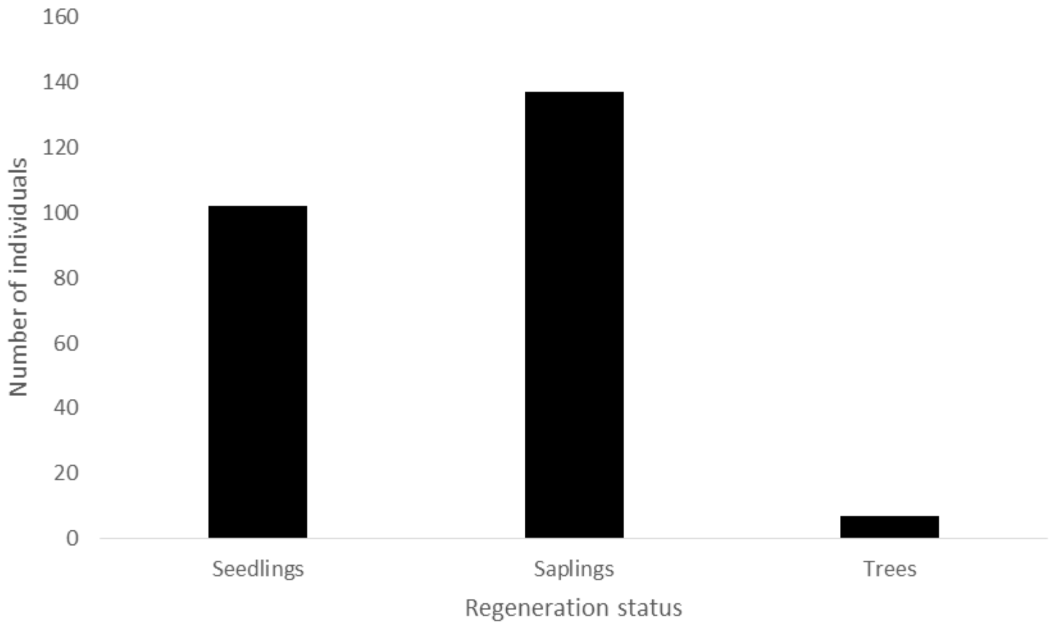

Fig. 2. Regeneration status of wetlands in Bamenda III Sub Division

At the species level, only *Bridelia micrantha* displayed a "good" regeneration potential. In contrast, regeneration was "poor" for *Canarium schweinfurthii*, *Funtimia africana* and *Ficus mucosa* and "fair" for *Pseudospondia microcarpa* and *Ficus lutea* (Table 5). Up to 80.65 % of woody species encountered had regeneration status as "new" (Table 3).

DISCUSSION

Regeneration of plants depends on a combination of factors controlling seed availability, germination, seedling growth and establishment. Environmental conditions play a crucial role in establishment and distribution of seedlings (Grubb, 1977, Bhat et al. 2020). The unfavorable nature of the growing medium for germination could therefore be brought forward as the main reason for the poor regeneration potential of woody species witnessed on the wetlands. Seed dormancy is an evolutionary adaptation that retains seed viability during environmental conditions which do not favour germination or seedling survival (Ungar, 2001). It plays a key role in maintaining soil seed banks. Some of such stressors include temperature, water, light, and salinity (Lambers et al. 2008; Gul et al. 2013). A good example of a species which exhibits seed dormancy is Canarium schweinfurthii whose hard testa presents a physical barrier to the uptake of water and oxygen for germination (Garba et al. 2023). It was found in a recent study that germination of C. schweinfurthii seeds can be induced by subjecting them to a warm water treatment that ameliorates the low soil temperature condition of the wetlands (Tanwie et al. 2023).

Table 3. Regeneration status of individual tree species in wetland

S/N	Species	Family	Seedlings	Saplings	Trees	Regeneration status
1	*Neoboutonia macrocalyx*	Euphorbiaceae	4	31	-	New
2	*Anthocleista grandiflora*	Gentianaceae	3	3	-	New
3	*Pseudospondia microcarpa*	Anacardiaceae	1	5	1	Fair
4	*Leandra balansae*	Melastomataceae	12	5	-	New
5	*Psychotria sp*	Rubiaceae	22	20	-	New
6	*Psidium guajava*	Myrtaceae	5	-	-	New
7	*Macaranga occidentalis*	Euphorbiaceae	5	11	-	New
8	*Syzygium polyanthum*	Mrytaceae	4	-	-	New
9	*Bridelia micrantha*	Phyllanthaceae	3	3	2	Good
10	*Albizia julibrissin*	Fabaceae	3	4	-	New
11	*Rauvolfia vomitoria*	Apocynaceae	3	4	-	New
12	*Voacanga africana*	Apocynaceae	5	6	-	New
13	*Ficus lutea*	Moraceae	1	-	1	Fair
14	*Vernonia amygdalina*	Asteraceae	9	8	-	New
15	*Canarium schweinfurthii*	Burseraceae	-	2	1	Poor
16	*Acalypha diversifolia*	Euphorbiaceae	9	6	-	New
17	*Kola nitida*	Sterculiaceae	-	2	-	New
18	*Vitex doniana*	Lamiaceae	2	1	-	New
19	*Albizia grandiflora*	Fabaceae	3	2	-	New
20	*Garcinia intermedia*	Clusiaceae	1	-	-	New
21	*Ficus equatus*	Moraceae	1	1	-	New
22	*Canthiumera robusta*	Rubiaceae	-	2	-	New
23	*Funtimia africana*	Apocynaceae	2	5	1	Poor
24	*Ficus exasperata*	Moraceae	-	3	-	New
25	*Polyscias fulva*	Araliaceae	-	2	-	New
26	*Trichilia americana*	Meliaceae	-	1	-	New
27	*Sterculia tragacantha*	Sterculiaceae	1	2	-	New
28	*Annona squamosa*	Annonaceae	1	1	-	New
29	*Carapa guianensis*	Meliaceae	-	3	-	New
30	*Ficus mucosa*	Moraceae	-	4	1	Poor
31	*Boehmeria caudata*	Urticaceae	2	-	-	New

The extremely high frequency of the "new" regeneration status was the outcome of human encroachment and felling of mature trees in the wetlands. Among other uses, the ecosystems are heavily exploited for food, construction material, utility poles, and medicine (Tanwie et al. 2024). In addition, they constitute a source of raw material for the local artisanal industry and land for replacement cultivation of crops and vegetables. This was, however, unlike the case in the Berbere Forest in the

Bale Zone of South East Ethiopia where the "new" regeneration status was associated with a recent introduction of the species on the site through seed dispersal by wind, insects and other animals (Bogale et al. 2017). On the other hand, the "good" regeneration potential exhibited exclusively by Bridelia micrantha may be explained by the fact that it is not a species of choice for exploitation by the local community since the tree does not grow very large in size. Furthermore, the seeds of B. micrantha mature, fall and germinate during the dry season when they are not swept away by flooding of the wetlands.

CONCLUSION

In general, the wood species were not of good regeneration status, with an overwhelming majority of the cases void of mother plants. This situation constitutes a great hindrance to conservation of woody species in wetlands of the Bamenda III municipality. To ensure sustainability of the ecosystems, it is necessary to explore physical, physiological, and quality attributes of the woody plant seeds so as to gain some insight into possible reasons for difficulties in germination. With that, it will be necessary to apply silvicultural techniques for regenerating the wetlands through artificial or natural means.

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