

# Floristic Diversity and Characterization of Peri-Urban Agriculture in Some Drains of the City of Douala (Cameroon)

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**How to cite this paper:** Bissemb, O.P., Ndjib, R.C., Mvogo Ottou, P.B., Ngotta Biyon, J.B., Ndiang, Z., Lamy Lamy, G.M., Tchatchouang, E.N., Nganmo, I.S., Betti, J.L. and Priso, R.J. (2025) Floristic Diversity and Characterization of Peri-Urban Agriculture in Some Drains of the City of Douala (Cameroon). *Journal of Environmental Protection*, 16, 719-738.  
<https://doi.org/10.4236/jep.2025.167037>

**Received:** June 24, 2025

**Accepted:** July 28, 2025

**Published:** July 31, 2025

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## Abstract

This study is situated within the context of rapid urbanization and the management of stormwater drains in Douala, aiming to assess the floristic diversity and agricultural practices in these disturbed environments, which play a key role in food security and ecological resilience for urban communities. The study involved an inventory of plants around five drains in Douala, conducted through floristic surveys. Species were identified and their abundance estimated, and floristic diversity was analyzed using the Shannon-Weaver and Pielou ecological indices. Similarity between sites was evaluated with the Sorensen index and a principal component analysis, with a particular focus on edible plants and local agricultural practices. A total of 67 species belonging to 24 families were recorded, with a marked dominance of Poaceae and pioneer genera such as Paspalum, Ipomoea, and Cyperus. Floristic diversity, measured by the Shannon-Weaver index ( $H' = 0.99$ ) and low evenness ( $E = 0.23$ ), indicates an unbalanced plant community dominated by a few cultivated and ruderal species. Additionally, 24 edible species mainly from the Solanaceae and Poaceae families were identified, highlighting the role of drains as urban agricultural spaces contributing to local food security. The floristic similarity analysis revealed significant homogenization between the Tongo Bassa and Kondi drains, suggesting common agricultural practices and environmental pressures. These results emphasize the need for integrated management aimed at diversifying crops and regulating agriculture in these polluted environments to preserve biodiversity, strengthen ecological resilience, and ensure food security for the neighboring populations.

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## Keywords

Floristic Inventory, Weeds, Peri-Urban Agriculture, Drains, Douala

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### 1. Introduction

Douala, the largest metropolis in Cameroon, is subject to recurrent flooding. In an effort to manage stormwater, the urban community of the city has undertaken the development of certain drains in recent years. However, these drains are under constant and increasing pressure due to rapid and uncontrolled urbanization, population growth, and related anthropogenic activities [1]. Around these drains, a rich floristic diversity is observed, ranging from adventitious species used for therapeutic purposes to agricultural plants intended for consumption by the neighboring populations [2].

In this context, peri-urban agriculture, particularly vegetable production, constitutes an essential activity for the supply of fresh products, while offering economic opportunities to often vulnerable local populations [3]. This agriculture, generally practiced on small plots located near drains, takes advantage of water availability and the fertility of alluvial soils but is also subject to specific environmental and socio-economic constraints [4].

However, it is important to highlight that these drains serve as dumping sites for all kinds of organic and synthetic waste such as plastic bottles and bags. Alongside these wastes, countless other liquid and solid wastes (some extremely small and unnoticed) are present. Cigarette butts, abundant among urban waste and carried by runoff water into the low-lying areas of the drains, constitute a major source of pollution. The highly toxic substances contained in cigarette butts (nicotine, heavy metals, microplastics) are capable of degrading water quality, soil, and local flora. From this perspective, cigarette butts pose a potential health risk to the riverside populations who cultivate and consume plants around the drains [1]. This issue is exacerbated by low public awareness and the absence of effective systems for the collection and treatment of specific wastes. It thus appears essential to identify the vulnerability factors of these ecosystems to pollution. Studying ecological similarities between different drains would help identify the resilience or vulnerability factors of these urban ecosystems.

A floristic inventory of plants cultivated around the drains would allow identification of the diversity of exploited species as well as associated farming practices. This approach is indispensable for understanding local agricultural dynamics and their interactions with peri-urban environments, which are often fragile and subject to risks of flooding or pollution (FAO, 2020). Furthermore, characterizing peri-urban agriculture in Douala sheds light on production systems and issues related to food security in a context marked by recent socio-political and health crises (internal displacement, COVID-19 pandemic) [3] [5].

In this context, the present study aims to evaluate floristic diversity and ecolog-

ical similarity and to characterize agriculture practiced in the drains of Douala. Specifically, it involved inventorying plants present around the drains of Douala, characterizing floristic diversity, and placing special emphasis on plants cultivated for human consumption.

## 2. Materials and Methods

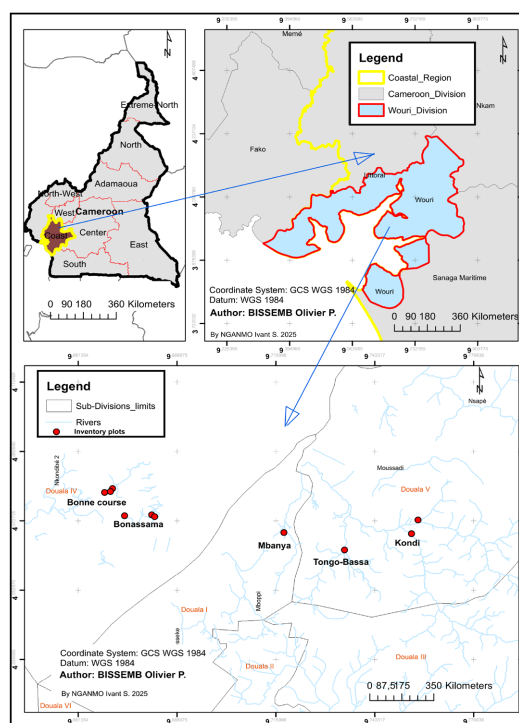
### 2.1. Materials

#### 2.1.1. Study Sites

The drains of Douala form a network of stormwater drainage infrastructures designed to combat the recurrent flooding in the city of Douala [6]. This city is located at the mouth of the Gulf of Guinea and includes nine main watersheds extending over approximately 250 kilometers of primary drains distributed throughout the city.

These drains serve several districts and boroughs, with varying lengths, for example: Mboppi (8230 m), Mgoua (12,060 m), Tongo Bassa (11,070 m), Mbanya (5720 m), New Bell Sud (3630 m), etc. The network regularly faces problems of blockage due to waste, tall grass, and illegal constructions, which require cleaning campaigns and awareness efforts to free the drain rights-of-way and ensure their proper functioning.

The study sites consisted of five drains in the city of Douala covering the natural watersheds of Kondi, Tongo Bassa, Mbanya, Bonassama, and Bonne Course (**Figure 1**).



**Figure 1.** Distribution map of plant inventory plots around the drains in the city of Douala (Cameroon). (Source: the author)

### 2.1.2. Inventory Equipment

The floristic inventory conducted in the drains was carried out using a form that took into account several parameters, the main ones being the date, site, GPS coordinates, habitat type, weather conditions, site condition, names of the plants found, usage categories, and their abundance levels.

A measuring tape, strings, a machete, and stakes were used to set up the plots. GPS coordinates were recorded using the Google Maps application for Android.

## 2.2. Methods

### 2.2.1. Inventory of Floristic Diversity in Selected Drains of the City of Douala

The floristic inventory was conducted in five drains in the city of Douala during May 2025. It was based on establishing plots or quadrats of 9 m<sup>2</sup> in area, measuring 3 m on each side. This plot size (9 m<sup>2</sup>) is often sufficient to capture a large portion of the species diversity present in a plant community. An ecosystem like a drain, which can exhibit a mosaic of herbaceous species, allows for the inclusion of both dominant and less frequent species within a representative area. It's also commonly used in vegetation studies to determine species richness at a local scale. In total, six plots, spaced 2 m apart, were established per drain from downstream to upstream, with three plots on each bank. For the five drains, a total of 30 plots were obtained.

Within each plot, five 1 m<sup>2</sup> quadrats were used for the phytosociological inventory (Figure 2). The plots were measured using a measuring tape and spaced at regular intervals of 2 m along the downstream-upstream direction, using fixed markers (stakes) and strings. The stakes were prepared in advance with a machete [7] [8].

This sampling protocol aims to provide a complete, precise, and spatially representative description of the floristic diversity and phytosociological composition of the studied drains, considering their specific nature and heterogeneity.



**Figure 2.** Illustration and layout of plots on cultivated lands around the drains.

After establishing the plots and quadrats, the species were recorded by assigning the Braun-Blanquet abundance-dominance coefficient corresponding to the spatial coverage percentage of each species within the quadrat.

Within each plot, the floristic survey consisted of compiling an exhaustive list

of all plant species present, with notation of the abundance-dominance coefficients for each species as defined by [9] [10], which range from the index “+” to the index “5”. This scale provides a classification of individuals of a species as follows:

- (+): number of individuals with a very low coverage degree ( $-1/20$ ), the mean coverage (MC) is 0.5%;
- (1): number of individuals with a low coverage degree ( $-1/20$ ), MC = 3%;
- (2): Abundant individuals covering at least  $1/20$  of the survey area; MC = 15%;
- (3): species with an abundant number of individuals covering between  $1/4$  and  $1/2$  of the total survey area; MC = 37.5%;
- (4): Abundant or non-abundant individuals, covering from  $1/2$  to  $3/4$  of the survey area, MC = 62.5%;
- (5): any number of individuals covering more than  $3/4$  of the survey area, MC = 87.5%.

Samples of all species collected *in situ* were harvested and stored in newspaper sheets, then pressed in a plant press for later identification. These plant samples were transported to the Laboratory of Biology and Physiology of Plant Organisms at the University of Douala (Cameroon) to facilitate their identification by the laboratory’s systematics specialists responsible for providing the scientific names of the plants. Samples of species cultivated for food were sent to the National Herbarium of Cameroon for specimen number assignment.

### 2.2.2. Characterization of Floristic Diversity

#### 1) Average coverage and Shannon-Weaver index in ecological studies

The mean cover (MC) is the percentage occupied by a species in a given environment:

$$MC_i = R_i / \text{Total number of plots}$$

and the presence index ( $P_i$ ) corresponds to the mean cover of species  $i$  relative to the total cover of all individuals:

$$P_i = MC_i / \sum MC$$

The Shannon-Weaver index ( $H'$ ) indicates the diversity or species richness of the environment and is therefore calculated using the following formula [7]:

$$H' = -\sum P_i \times \ln(P_i)$$

#### 2) Pielou’s Evenness Index

The evenness index, or Pielou’s evenness ( $R$ ), is defined as:

$$R = H' / H'_{\max}$$

where  $H'_{\max}$  is the maximum diversity, calculated as  $\ln(S)$ , with  $S$  being the number of species. Evenness reflects the relative disorder of the population. It approaches 0 when nearly all individuals are concentrated in a single species, and equals 1 when all species have the same abundance. A low evenness indicates the greater or lesser dominance of a few species [11].

#### 3) Sorensen similarity coefficient

The Sorensen similarity coefficient places significant emphasis on the joint presence of two species in the same location. It is defined as:

$$Q = [2a/2a + b + c] \times 100$$

where

$0 < Q < 100$ , and:

- A = number of species common to both environments;
- b = number of species present in environment A but absent in environment B;
- c = number of species present in environment B but absent in environment A.

This coefficient allows for assessing the similarities between plant communities [12].

### 2.2.3. Characterization of the Diversity of Cultivated Plants along Drains for Human Consumption

The diversity of cultivated plants was characterized by calculating the three previously described indices, namely: the average coverage and the Shannon-Weaver diversity index, Pielou's evenness index, and Sorensen's similarity coefficient.

Subsequently, a principal component analysis was performed based on the different cultivated plants to investigate the correlations between the various drains and the plants grown there.

## 2.3. Statistical Analyses

Microsoft Excel 2016 was used for graphical representations, frequency calculations, and the computation of the Sorensen similarity index, Shannon-Weaver diversity index, and Pielou's evenness index.

RStudio version 4.4.0 was employed to perform principal component analysis (PCA), and the study site maps were created using ArcGIS or ArcMap 10.8.0.

## 3. Results

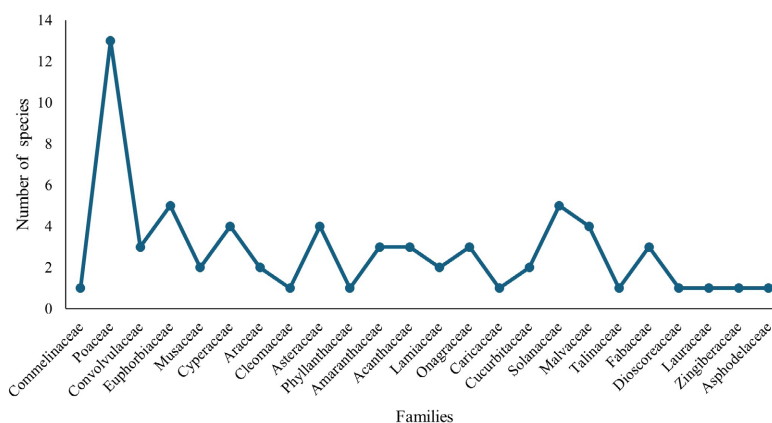
### 3.1. Inventory of Floristic Diversity in the Drains

The floristic diversity inventory conducted in this study identified 67 species distributed across 52 genera and belonging to 24 families. The Poaceae family was predominant, with 13 species (Figure 3).

The genera *Paspalum* (4 species), *Ipomoea* (3 species), *Cyperus* (4 species), *Ludwigia* (3 species), and *Solanum* (3 species) dominated the overall vegetation.

### 3.2. Characterization of Floristic Diversity

The analysis of the floristic diversity index shows that the entire drain network is highly diverse, as reflected by a Shannon-Weaver value of 0.99 bits. The calculated evenness was very low (0.23). This low value indicates the dominance of a few species, including weeds and cultivated plants used for food, namely: *Commelina benghalensis* L. (0.0733951), *Zea mays* (0.07390314), *Musa sapientum* L. (0.07680161), *Musa paradisiaca* L. (0.06654107), *Xanthosoma sagittifolium* Schott (0.06132289), and *Solanum nigrum* L. (0.03395552).



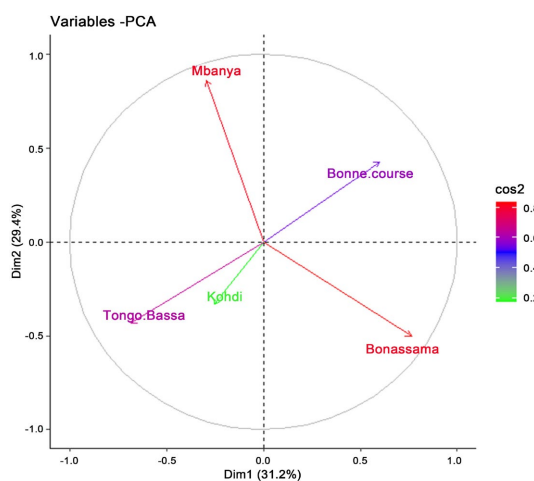
**Figure 3.** Distribution of species by botanical families.

The calculation of similarity coefficients between the different drains (**Table 1**) shows that only the Tongo-Bassa and Kondi drains have a significant similarity, with a value of 71.43%. This similarity clearly indicates that these two drains share the same floristic composition.

**Table 1.** Sorensen similarity coefficient of all species recorded in the five drainage systems.

	Bonne course	Bonassama	Mbanya	Kondi	Tongo-Bassa
Bonne course	100				
Bonassama	35.09	100			
Mbanya	41.94	40.58	100		
Kondi	37.04	49.18	48.48	100	
Tongo-Bassa	38.46	44.07	53.13	71.43	100

The Principal Component Analysis (**Figure 4**) also shows that only the Tongo-Bassa and Kondi drains exhibit similarity along the Dim1 axis (31.2%).



**Figure 4.** Principal component analysis.

The floristic diversity is summarized in **Table 2** below:

**Table 2.** List of all plants species inventoried.

Plant species	Drains										Indices of the Different Plant Species				
	Bonne course	Bonassama	Mbanya	Kondi	Tongo-Bassa	PPSD	RPSAD	MC	MC <sub>r</sub>	P <sub>r</sub>	Ln(P <sub>r</sub> )	H'			
<i>Abelmoschus esculentus</i> (L.) Moench	0	0	1	0	1	2	1.42857143	30	6	0.00493873	-5.31064682	0.02622786			
<i>Acalypha alopecuroides</i> Jacq.	0	0	1	0	0	1	0.71428571	0.5	0.1	8.23122E-05	-9.40499138	0.00077415			
<i>Acroceras zizanioides</i> (kunth.) Dandy	0	0	1	0	1	2	1.42857143	3.5	0.7	0.000576185	-7.45908123	0.00429781			
<i>Ageratum conyzoides</i> L.	1	1	1	0	1	4	2.85714286	15.75	3.15	0.002592834	-5.95500383	0.01544034			
<i>Aloe africana</i> Mill.	0	1	0	1	0	2	1.42857143	1	0.2	0.000164624	-8.7118442	0.00143418			
<i>Amaranthus spinosus</i> L.	0	0	1	1	1	3	2.14285714	30.275	6.055	0.004984003	-5.30152191	0.0264228			
<i>Amaranthus viridis</i> L.	0	1	0	1	1	3	2.14285714	4	0.8	0.000658497	-7.32554984	0.00482386			
<i>Asystasia gangetica</i> (L.) T. Anderson	0	0	1	0	0	1	0.71428571	2.375	0.475	0.000390983	-7.84684676	0.00306798			
<i>Asystasia vogeliana</i> Benth.	0	1	0	0	0	1	0.71428571	3	0.6	0.000493873	-7.61323191	0.00375997			
<i>Axonopus compressus</i> (Sw.) P. Beauv.	1	0	0	0	0	1	0.71428571	63.125	12.625	0.010391914	-4.56672731	0.04745704			
<i>Capsicum annuum</i> L.	0	1	0	0	0	1	0.71428571	3	0.6	0.000493873	-7.61323191	0.00375997			
<i>Capsicum frutescens</i> L.	0	0	0	1	1	2	1.42857143	3.5	0.7	0.000576185	-7.45908123	0.00429781			
<i>Carica papaya</i> L.	1	1	1	1	0	4	2.85714286	12.6666667	2.533333333	0.002085242	-6.17287033	0.01287193			
<i>Genchrus purpureus</i> (Schumacher) Morrone	0	0	1	0	0	1	0.71428571	6	1.2	0.000987746	-6.92008473	0.00683529			
<i>Coleus monostachyus</i> (P. Beauv.) Briq.	1	1	1	0	0	3	2.14285714	1.5	0.3	0.000246937	-8.30637909	0.00205115			
<i>Colocasia esculenta</i> (L.) Schott	0	1	1	1	1	4	2.85714286	7.833333333	1.56666667	0.001289558	-6.65345607	0.00858001			
<i>Commelina benghalensis</i> L.	1	1	1	1	1	5	3.57142857	111.525641	22.3051282	0.018359839	-3.99758967	0.0733951			
<i>Corchorus olitorius</i> L.	0	0	1	1	1	3	2.14285714	25.75	5.15	0.004239078	-5.46340957	0.02315982			
<i>Cucumis melo</i> L.	0	0	1	1	1	3	2.14285714	20.9375	4.1875	0.003446823	-5.67030239	0.01954453			
<i>Curatma longa</i> L.	0	1	0	0	0	1	0.71428571	0.5	0.1	8.23122E-05	-9.40499138	0.00077415			
<i>Cyathium cinereum</i> (L.) H. Rob.	0	1	1	0	0	2	1.42857143	1.66666667	0.333333333	0.000274374	-8.20101858	0.00225015			
<i>Cyathula prostrata</i> (L.) Blume	0	1	0	1	0	2	1.42857143	1	0.2	0.000164624	-8.7118442	0.00143418			
<i>Cymbopogon citratus</i> (D. C.) Stapf.	0	1	0	1	1	3	2.14285714	24	4.8	0.003950985	-5.53379037	0.02186392			
<i>Cyperus cylindrostachyus</i> Boeckler	1	0	0	0	0	1	0.71428571	2.375	0.475	0.000390983	-7.84684676	0.00306798			

## Continued

<i>Cyperus esculentus</i> L.	0	0	1	1	0	0	0	0	0	0.1	8.23122E-05	-9.40499138	0.00077415
<i>Cyperus odoratus</i> L.	0	0	1	1	0	0	0	0	0	0.1	8.23122E-05	-9.40499138	0.00077415
<i>Cyperus rotundus</i> L.	1	0	1	1	0	0	0	0	2	0.2	0.000164624	-8.7118442	0.00143418
<i>Dioscorea bulbifera</i> L.	0	1	0	0	1	0	0	0	2	0.7	0.000576185	-7.45908123	0.00429781
<i>Eclipta prostrata</i> L.	1	1	0	0	0	0	0	0	2	0.7	0.000576185	-7.45908123	0.00429781
<i>Eleusine indica</i> (L.) Gaertn.	1	0	1	1	1	0	0	0	3	7.1	0.005844165	-5.1423115	0.03005252
<i>Erenomastax speciosa</i> (Hochst.) Cufod	0	1	0	0	0	0	0	0	1	0.6	0.000493873	-7.61323191	0.00375997
<i>Euphorbia hirta</i> L.	1	1	0	0	0	0	0	0	2	1.55	0.001275839	-6.66415136	0.00850238
<i>Euphorbia hyssopifolia</i> L.	0	0	1	1	0	0	0	0	1	0.1	8.23122E-05	-9.40499138	0.00077415
<i>Gymnanthemum amygdalinum</i> Delile	0	1	0	0	1	1	1	1	3	9.5	0.007819658	-4.85111449	0.03793406
<i>Ipomoea batatas</i> (L.) Lam.	1	0	1	1	1	1	1	1	4	5.683333333	0.004678076	-5.36486837	0.02509726
<i>Ipomoea carica</i> (L.) Sweet	0	1	1	1	0	0	0	0	2	0.2	0.000164624	-8.7118442	0.00143418
<i>Ipomoea involucreta</i> P.Beauv.	0	1	1	1	0	0	0	0	2	0.2	0.000164624	-8.7118442	0.00143418
<i>Jatropha curcas</i> L.	0	1	0	0	1	1	1	1	3	6.1	0.005021043	-5.29411752	0.02658199
<i>Ludwigia adscendens</i> (L.) Hara	0	0	1	1	0	0	0	0	1	0.1	8.23122E-05	-9.40499138	0.00077415
<i>Ludwigia decurrens</i> Walter	0	0	1	1	0	0	0	0	1	0.1	8.23122E-05	-9.40499138	0.00077415
<i>Ludwigia repens</i> [R]Forst.	0	0	1	1	0	0	0	0	1	0.1	8.23122E-05	-9.40499138	0.00077415
<i>Manihot esculenta</i> Crantz	0	1	0	0	0	0	0	0	2	4.375	0.003601158	-5.62649977	0.02026192
<i>Mimosa pudica</i> L.	1	0	0	0	0	0	0	0	1	0.225	0.000185202	-8.59406116	0.00159164
<i>Momordica foetida</i> Schum.	1	0	0	0	0	0	0	0	1	3.1	0.002551678	-5.97100418	0.01523608
<i>Musa paradisiaca</i> L.	0	1	1	1	1	1	1	1	4	19.585	0.016120842	-4.12764232	0.06654107
<i>Musa sapientum</i> L.	1	1	1	1	0	0	0	0	4	23.7	0.019507988	-3.93693124	0.07680161
<i>Neustanthus phaseoloides</i> (Roxb.) Benth.	1	0	0	0	0	0	0	0	1	0.1	8.23122E-05	-9.40499138	0.00077415
<i>Ocimum gratissimum</i> L.	0	1	0	0	0	0	0	0	2	0.7	0.000576185	-7.45908123	0.00429781
<i>Paspalum conjugatum</i> P. J. Bergius.	0	0	1	1	1	1	1	0	2	1.24285714	0.001023023	-6.88499341	0.00704351
<i>Paspalum dilatatum</i> Poir.	0	0	1	1	1	1	1	1	3	1.3	0.001070058	-6.84004202	0.00731924
<i>Paspalum scrobiculatum</i> Linn.	1	0	1	1	1	1	1	1	4	0.9	0.00074081	-7.2077668	0.00533958

Continued

<i>Persea americana</i> Mill.	0	1	0	0	0	0	0	0	0.1	8.23122E-05	-9.40499138	0.00077415
<i>Phyllanthus amarus</i> Schumach. & Thonn.	1	1	1	0	1	4	8.055	1.611	0.001326049	-6.62555118	0.00878581	
<i>Poa annua</i> Linn.	0	1	1	0	0	2	3.5	0.7	0.000576185	-7.45908123	0.00429781	
<i>Saccharum officinarum</i> Linn.	0	1	0	1	0	2	38.66666667	7.733333333	0.006365476	-5.0568663	0.03218936	
<i>Senna occidentalis</i> (L.) Link	1	0	0	0	0	1	16.2311	3.24622	0.002672035	-5.92491504	0.01583158	
<i>Setaria barbata</i> (Lam.) Kunth	0	1	0	1	0	2	3.5	0.7	0.000576185	-7.45908123	0.00429781	
<i>Sida acuta</i> Burm.fil.	1	0	0	0	0	1	0.5	0.1	8.23122E-05	-9.40499138	0.00077415	
<i>Sieruela rufidisperma</i> DC.	0	0	1	1	1	3	10.5	2.1	0.001728556	-6.36046894	0.01099443	
<i>Solanum gilo</i> Raddi	0	0	0	1	1	2	10.75	2.15	0.001769712	-6.33693844	0.01121456	
<i>Solanum nigrum</i> L.	1	1	1	1	0	4	41.33333333	8.266666667	0.006804474	-4.99017492	0.03395552	
<i>Solanum torvum</i> Sw.	1	0	0	1	1	3	38.75	7.75	0.006379194	-5.05471344	0.032245	
<i>Synedrella nodiflora</i> L. (Gaertn.)	0	0	1	0	0	1	3	0.6	0.000493873	-7.61323191	0.00375997	
<i>Talinum fruticosum</i> (L.) Juss.	1	0	0	1	1	3	21	4.2	0.003457112	-5.66732176	0.01959257	
<i>Urena lobata</i> Linn.	1	0	0	0	0	1	0.5	0.1	8.23122E-05	-9.40499138	0.00077415	
<i>Xanthosoma sagittifolium</i> (L.) Schott	1	1	1	1	1	5	87.95833333	17.5916667	0.014480086	-4.23498098	0.06132289	
<i>Zea mays</i> L.	1	0	1	1	1	4	112.556733	22.5113467	0.018529582	-3.98838681	0.07390314	
Richesse des espèces par drain (S)	22	31	35	27	25	140	100	1214.88693			0.98698267	
Fréquences d'occurrences de toutes les espèces végétales par drain (%)	15.7142857	22.1428571	25	19.2857143	17.8571429	100						

**Legend:** MC = mean coverage;  $MC_j$  = mean coverage of species  $j$ ;  $P_j$  = presence index of species  $j$ ;  $\ln(P)$  = logarithm of the presence index  $P$ ;  $H'$  = Shannon-Weaver index;  $H'_{max}$  = maximum diversity ( $\ln(S)$ , where  $S$  = species richness per drain);  $Pr$  = relative presence of a species across all drains;  $PPSD$  = Presence of a Plant Species Across All Drains,  $RPSAD$  = Relative Presence (Pr) of a Species Across All Drains (%). Let  $H'_{max} = 4.20469262$  and the evenness index  $R = 0.23473361$ .

### 3.3. Characterization of the Diversity of Cultivated Plants in the Drains for Human Consumption

The analysis of vegetation cover in the drains of Bonassama, Bonne Course, Mbanya, Kondi, and Tongo-Bassa identified 24 edible plant species, distributed across 21 genera and grouped into 15 families. The Solanaceae and Poaceae families are the most cultivated, with 4 and 3 species respectively (**Table 3**).

**Table 3.** List of edible species inventoried.

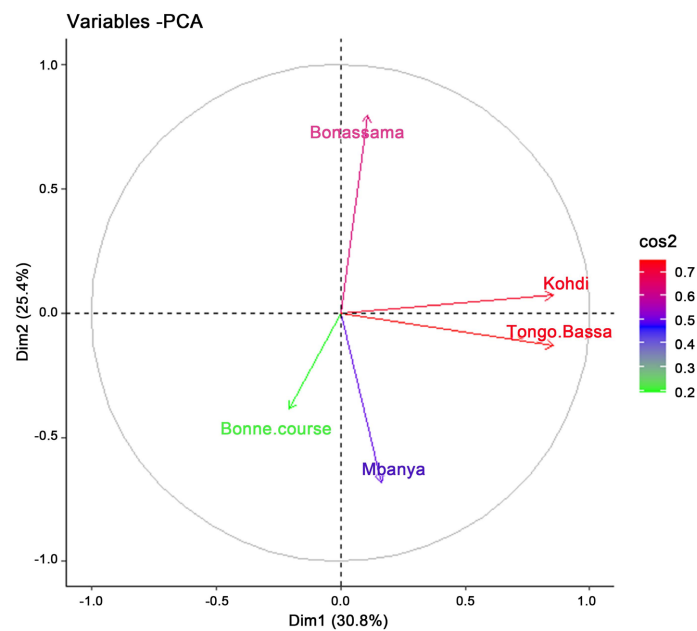
Families	Plant species	Specimen number
	<i>Zea mays</i> L.	18,625 SRFCam
Poaceae	<i>Cymbopogon citratus</i> (DC.) Stapf	18,628 SRFCam
	<i>Saccharum officinarum</i> L.	42,958 SRFCam
Convolvulaceae	<i>Ipomoea batatas</i> Lam.	55,594 SRFCam
Musaceae	<i>Musa sapientum</i> L.	67,491 HNC
	<i>Musa paradisiaca</i> L.	67,495 HNC
Araceae	<i>Xanthosoma sagittifolium</i> (L.) Schott	18,675 SRFCam
	<i>Colocasia esculenta</i> (L.) Schott	52,357 SRFCam
Amaranthaceae	<i>Amaranthus viridis</i> L.	7732 SRFCam
Euphorbiaceae	<i>Manihot esculenta</i> Crantz	57,651 SRFCam
	<i>Jatropha curcas</i> L.	25,713 SRFCam
Caricaceae	<i>Carica papaya</i> L.	18,647 SRFCam
Cucurbitaceae	<i>Cucumis melo</i> L.	18,562 SRFCam
	<i>Solanum nigrum</i> L.	34,762 SRFCam
Solanaceae	<i>Capsicum annuum</i> L.	25,872 SRFCam
	<i>Solanum gilo</i> Raddi	18,631 SRFCam
	<i>Capsicum frutescens</i> L.	43,058 SRFCam
Malvaceae	<i>Abelmoschus esculentus</i> (L.) Moench	42,870 SRFCam
	<i>Corchorus olitorius</i> L.	44,860 SRFCam
Talinaceae	<i>Talinum fruticosum</i> (L.) Juss.	42,141 SRFCam
Asteraceae	<i>Gymnanthemum amygdalinum</i> (Delile) <i>Sch.Bip. ex Walp.</i>	23,625 SRFCam
Dioscoreaceae	<i>Dioscorea bulbifera</i> L.	50,412 SRFCam
Lamiaceae	<i>Ocimum gratissimum</i> L.	42,738 SRFCam
Zingiberaceae	<i>Curcuma longa</i> L.	42,173 SRFCam

The species *Musa sapientum* L. and *Musa paradisiaca* L. (Musaceae) are some of plants species recognized around the drains (**Figure 5**), although collected and identified by the botanists of the Laboratory, have not yet been deposited in the National Herbarium of Cameroon and therefore do not yet have registered specimen numbers.



**Figure 5.** Photos of some cultivated plants in the drains of Douala.

Principal Component Analysis (**Figure 6**) allowed the classification of the different drains according to the types of crops cultivated. This analysis shows that the drains of Kondi and Tongo-Bassa share a similar floristic background of edible plants along the Dim2 axis (25.4%).



**Figure 6.** Correlation among the different drains based on crop types.

The calculated Sorensen index reveals similarities between the stations Bonne Course and Bonassama (64%); Bonne Course and Mbanya (54.55%); Bonne Course and Kondi (51.85%); Bonassama and Kondi (64.52%); Bonassama and Tongo-Bassa (53.33%); Mbanya and Kondi (51.85%). However, the stations Kondi and Tongo-Bassa exhibit the highest similarity, at 70.97% (**Table 4**).

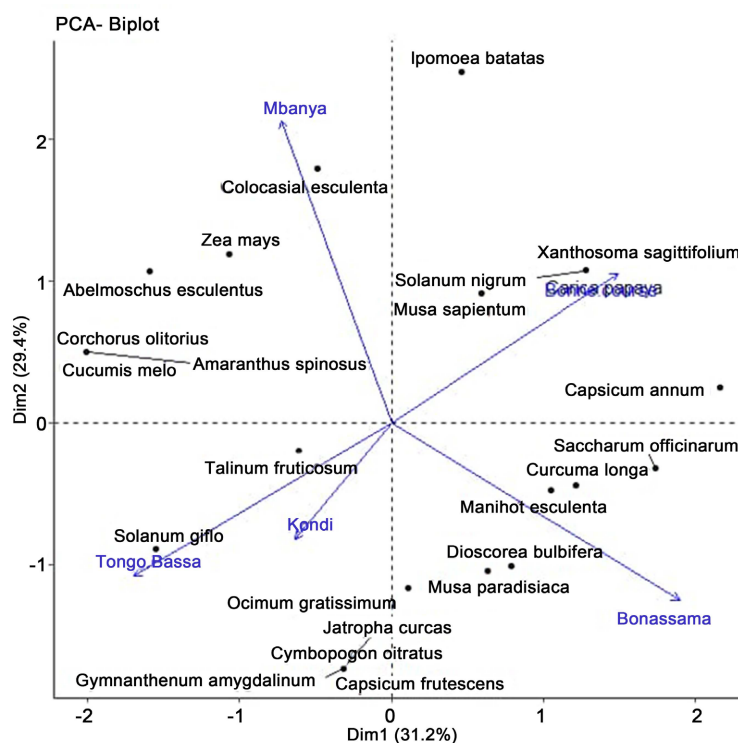
**Figure 7** illustrates the biplot showing the distribution of inventoried edible species according to the drains.

The biplot shows that species such as *Solanum gilo* and *Talinum fruticosum* have a stronger affinity with the Tongo Bassa and Kondi sites compared to the other three sites. Similarly, *Capsicum annum* is the species most closely associ-

ated with the Bonassama and Bonne Course sites.

**Table 4.** Sorensen similarity index of edible species.

	Bonne course	Bonassama	Mbanya	Kondi	Tongo-Bassa
Bonne course	100				
Bonassama	64	100			
Mbanya	54.55	30.77	100		
Kondi	51.85	64.52	51.85	100	
Tongo-Bassa	40	53.33	46.15	70.97	100



**Figure 7.** Biplot of the distribution of edible species cultivated in the drains.

The analysis of the overall floristic diversity index indicates that the drains are moderately diverse, as reflected by a Shannon-Weaver value of 0.99 bits. The calculated evenness is very low, at 0.23. This low value indicates the dominance of a few cultivated species, notably: *Zea mays* (0.0739), *Musa sapientum* L. (0.0768), *Musa paradisiaca* L. (0.0665), *Xanthosoma sagittifolium* Schott (0.0613), and *Solanum nigrum* (0.0340).

## 4. Discussion

### 4.1. Species Richness and Taxonomic Diversity

The floristic inventory recorded 67 species distributed across 52 genera and 24 families, with a clear dominance of Poaceae (13 species). This finding is consistent

with several studies conducted in similar ecosystems, particularly in tropical and subtropical regions.

A total of 67 species from 24 families indicates a moderate to high floristic diversity, typical of open or disturbed environments. According to [12], plant diversity in tropical regions varies greatly depending on the intensity of disturbances and land-use history. The dominance of a few families, especially Poaceae as observed in this study, is frequently reported in inventories of savannas, grasslands, or anthropized areas [13]. The Poaceae family is often the most represented in floristic surveys of open habitats due to its high adaptability and colonization capacity [14]. Poaceae play a key ecological role in structuring plant communities, stabilizing soils, and providing food resources for wildlife [15].

The dominance of the genera *Paspalum*, *Ipomoea*, *Cyperus*, *Ludwigia*, and *Solanum* can be explained by the fact that these genera are widely represented in tropical and subtropical floras. They are frequently encountered in floristic inventories of open, agricultural, or wet environments, especially in West Africa, where they rank among the dominant families and genera of plant communities [16].

Moreover, these genera are all known to include pioneer or ruderal species capable of rapidly colonizing disturbed or anthropized habitats such as agricultural fields, drains, roadsides, or rice paddies [16]. They thus play an important role in the dynamics of plant succession and the resilience of ecosystems in response to disturbances.

Finally, several species belonging to these genera have nutritional, forage, or medicinal value, which explains their frequent presence in lists of useful plants recorded during floristic inventories in rural or urban environments [16]. Moreover, these predominant genera share common characteristics, particularly regarding their habitats: *Cyperus* and *Paspalum* preferentially grow in wet or temporarily flooded environments, suggesting the presence of diverse microhabitats within the studied drains [17]; *Ludwigia* is typical of wetland and riparian zones, which supports the ecological diversity of the site [18].

Some genera are also closely related based on their geographic distribution; *Ipomoea* and *Solanum* are cosmopolitan and often indicators of disturbance or nutrient-rich soils, as is the case for the drains in Douala, which are known to serve as dumping sites for various types of waste [19].

The dominance of these genera reflects a mosaic of habitats and a possible anthropogenic influence, favoring pioneer or ruderal species.

Similar results were reported by [20] in the savannas of West Africa, where Poaceae and Cyperaceae largely dominate the flora. Likewise, [21] observed a strong representation of the genera *Paspalum* and *Cyperus* in the wetlands of Brazil.

## 4.2. Characterization of Floristic Diversity

The analysis of floristic diversity using the Shannon-Weaver index ( $H' = 0.99$  bits) indicates a relatively low to moderate diversity, well below the values observed in highly diverse ecosystems, where  $H'$  often exceeds 1.5 or even 2 bits.

This value suggests that, although several species are present, the community is dominated by a few very abundant species, which is confirmed by the low evenness (Pielou's equitability,  $E = 0.23$ ). Such low evenness reflects a marked imbalance in the distribution of individuals among species, a phenomenon typical of disturbed environments or those under strong anthropogenic pressure, as is the case for these drains, which are not only polluted but also heavily used by local populations practicing subsistence agriculture.

The dominant species identified (*Commelina benghalensis*, *Zea mays*, *Musa sapientum*, *Musa paradisiaca*, *Xanthosoma sagittifolium*, and *Solanum nigrum*) include both weed and cultivated plants, reflecting the human influence on the floristic composition of the studied drains. This finding aligns with observations from several recent studies on agroecosystems and anthropized environments, where floristic diversity is often reduced and dominated by ruderal or cultivated species [22].

The coexistence of ruderal and cultivated species in polluted areas can be explained by the intrinsic adaptability of ruderal plants to disturbed and stressful environments, combined with human selection and management strategies for cultivated species, sometimes in synergy with the ruderals. This is an example of the resilience of plant life in the face of anthropogenic pressures, even though it raises questions about food safety and the impact of consuming these crops.

The high floristic similarity (71.43%) between the Tongo-Bassa and Kondi drains, revealed by the similarity coefficient, indicates a common floristic background, likely related to similar ecological conditions or comparable agricultural practices. This result is frequently observed in floristic comparison studies between nearby sites or those subjected to similar land uses, where species composition tends to converge [22].

In this study, the Kondi and Tongo-Bassa drains, although geographically distant, share a similar floristic background, indicating that the same plant species are found in both sites. This could result from the familiarity of the local populations, who share common origins and, consequently, similar agricultural practices or are subjected to the same socio-economic constraints.

Furthermore, the low Shannon-Weaver index value, combined with very low evenness and the dominance of ruderal and cultivated species, reflects limited species diversity and a strong anthropogenic influence on the flora of the studied drains, as observed in a study conducted in southern Niger [23].

This inventory was conducted after the short rainy season in Douala. With the return of the rains, people joyfully sow legumes and other short-cycle leafy vegetables. This is certainly why the crops aren't diverse, with a predominance of maize. The cultivation of this Poaceae is very popular with the local population during this season.

#### 4.3. Diversity of Edible Plants Inventoried in Urban Drains

The inventory of 24 edible plant species, distributed across 21 genera and 15 fam-

ilies, in the drains of Bonassama, Bonne Course, Mbanya, Kondi, and Tongo-Bassa highlights the richness and diversity of both cultivated and spontaneous plant resources in these urban drains of Douala. The predominance of Solanaceae (4 species) and Poaceae (3 species) among the cultivated plants is particularly noteworthy.

The presence of 24 edible species in urban drains aligns with trends observed in other major African cities, where marginal spaces (drains, riverbanks, fallow lands) serve as refuges for a diversity of food plants [23] [24]. This diversity contributes to urban food security, household self-sufficiency, and resilience against food insecurity [25].

The Solanaceae and Poaceae families are dominant among the edible plants recorded in the drains. Solanaceae, which include species such as chili peppers (*Capsicum frutescens* and *Capsicum annuum*), black nightshade (*Solanum nigrum*), as well as tomatoes and eggplants, are highly valued for their nutritional content and culinary uses [26]. Poaceae, on the other hand, comprise major cereals such as maize (*Zea mays*), which appeared among the dominant plants in the drains at the time of the inventory. This cereal, along with rice, is essential in the staple diet [27]. According to [28], these two families are the most represented in urban agricultural systems in West Africa due to their adaptability, short growth cycles, and high demand in local markets.

Urban drains, often perceived as degraded environments, appear to play an important ecological role in maintaining useful plant diversity [24]. They also serve as micro-gardens for local populations, who cultivate species with high nutritional or medicinal value [23]. This practice contributes to combating urban poverty and promotes local agrodiversity [25].

Similar results have been obtained in Accra (Ghana) and Cotonou (Benin), where urban drains and wetlands harbor a comparable diversity of edible species, with a dominance of Solanaceae and Poaceae [23] [28]. These observations confirm that the Solanaceae and Poaceae families are pillars of African urban agriculture and, in cases of pollution, the cultivation and consumption of these plants should be carefully monitored.

Floristic similarity between the drains was assessed using various indices; the Sorensen index revealed moderate to high similarity values between the different study sites, with a maximum of 70.97% between Kondi and Tongo-Bassa. Consequently, the floristic composition of these two drains is relatively homogeneous. These results provide valuable insights into the dynamics of plant diversity in urban environments, particularly regarding the types of plants cultivated there. This suggests similar ecological conditions, agricultural practices, or anthropogenic pressures [23] [28]. The highest similarity observed between Kondi and Tongo-Bassa (70.97%) corroborates the Principal Component Analysis, which had already highlighted a common floristic background between these two drains.

Several factors may explain these levels of similarity, notably geographic proximity and ecological continuity. According to [24], nearby sites may share the

same plant species due to seed dispersal, habitat connectivity, and the exchange of plant material. Furthermore, agricultural practices and land use may be influenced by the adoption of similar cultivation techniques resulting from the ethnic mixing observed around the drains, the selection of adapted edible plants, and community management of the drains, thereby promoting floristic homogenization [25]. The similarity between the drains could also be explained by the strong common anthropogenic pressure on them. Indeed, urbanization and waste management can limit diversity and favor certain ruderal or cultivated species, increasing the resemblance between sites [23].

Comparable similarity values have been reported in other African urban contexts. For example, in Cotonou and in Abidjan, Sorensen indices were observed to range from 50% to 75% between different neighborhoods, highlighting the influence of urban practices on floristic composition [23] [28]. Similarly, [24] note that collective management of urban spaces promotes convergence of both cultivated and spontaneous flora.

High floristic similarity can be seen as an advantage for coordinated management of urban green spaces, but it also indicates a certain homogenization that may reduce ecological resilience to disturbances [25]. Therefore, it is recommended that the diversification of cultivated species be promoted to strengthen ecological stability and urban food security [27]. Regarding food security, it thus seems essential to regulate agricultural activities in drains and, above all, to raise awareness and control the safety of food products derived from these activities.

The Shannon-Weaver index ( $H' = 0.99$  bits) obtained for all drains indicates moderate floristic diversity. This index, widely used to assess the richness and balance of plant communities, typically ranges between 1.5 and 3.5 in highly diverse natural ecosystems [29]. Values below 1.5 often reflect marked dominance by a few species and low evenness, as is the case here.

Recent studies conducted in African urban environments report similar or slightly higher values, particularly in areas subjected to strong anthropogenic or agricultural pressure [23] [28]. This can be explained by the transformation of natural habitats, the selection of high-yield or food-use species, and the presence of ruderal species adapted to disturbances [24].

Evenness (Pielou's equitability,  $E = 0.23$ ) is very low, indicating that most individuals belong to a small number of dominant species. This situation is typical of urban agroecosystems, where agricultural practices favor certain species at the expense of others [25]

The dominance of *Zea mays*, *Musa sapientum*, *Musa paradisiaca*, *Xanthosoma mafaffa*, and *Solanum nigrum* among cultivated plants reflects the importance of these species in the local diet and their adaptation to the conditions of urban drains. Studies by [23] and [26] show that these species are frequently cultivated in urban gardens and marginal spaces in West Africa due to their nutritional value, short growth cycles, and tolerance to variable conditions.

The predominance of these species also reflects floristic homogenization, often

observed in urban environments where plant diversity is strongly influenced by the dietary needs and agricultural practices of local populations [24] [26].

Low diversity and reduced evenness may make these urban agroecosystems more vulnerable to diseases, pests, and environmental changes [27].

This study, which aimed to inventory the plants present in Douala's drains, doesn't highlight the degree of pollution by cigarette butts or measured social impacts. It represents the initial phase of studying cigarette butt pollution in these drains. It would be important to determine the degree of pollution and, more importantly, the level of awareness among riparian populations regarding the pollution of the lands they cultivate by this type of waste: cigarette butts.

## 5. Conclusions

This study evaluated floristic diversity and ecological similarity and characterized the agriculture practiced in the drains of Douala. The inventory revealed a moderate to high floristic diversity with 67 species distributed across 52 genera and 24 families, dominated by Poaceae, which corresponds to observations in open or disturbed environments in tropical and subtropical regions. The dominance of pioneer and ruderal genera such as *Paspalum*, *Ipomoea*, *Cyperus*, *Ludwigia*, and *Solanum* highlights anthropogenic influence and the presence of varied microhabitats within these drains, characterized by specific ecological conditions and strong human pressure. The Shannon-Weaver index ( $H' = 0.99$ ) and low evenness ( $E = 0.23$ ) reflect a plant community dominated by a few species, indicating an imbalance typical of disturbed environments subjected to subsistence agriculture.

Furthermore, the inventory of edible plants highlighted the nutritional richness of urban drains, with 24 species distributed across 21 genera and 15 families, where Solanaceae and Poaceae play a key role in local food security. The high floristic similarity between certain drains, notably Kondi and Tongo-Bassa, indicates similar agricultural practices and anthropogenic pressures, promoting floristic homogenization that may limit ecological resilience. These findings demonstrate that drains serve as important habitats for valuable plant biodiversity and urban agriculture, contributing to the self-sufficiency of local communities.

We cannot encourage the promotion of food crop cultivation as long as the degree of pollution remains unknown. We advocate for integrated management and crop diversification, favoring species that do not accumulate heavy metals from polluted soils or those that possess a high purification capacity. This study thus provides valuable insights for the sustainable and coordinated management of urban green spaces in the context of strong anthropogenic pressure and increasing urbanization.

## Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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