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Practice and Biodiversity of Informal Ornamental Horticulture in Kinshasa, Democratic Republic of Congo

Léa Mukubu Pika [1,*], Trésor Mbavumoja Selemani [2], Roselande Jesuka [1], Jean Pierre Pitchou Meniko To Hulu [3], Kouagou Raoul Sambieni [2,4], Yannick Useni Sikuzani [5] and Jan Bogaert [1,*]

1 Gembloux Agro-Bio Tech, Université de Liège, 5030 Gembloux, Belgium; roselande.jesuka@doct.uliege.be
2 Ecole Régionale Post-Universitaire d'Aménagement et de Gestion Intégrés des Forêts et Territoires Tropicaux (ERAIFT), Kinshasa P.O. Box 15373, Democratic Republic of the Congo; tmselemani@outlook.fr (T.M.S.); krsambieni@uliege.be (K.R.S.)
3 Laboratoire d'Ecologie du Paysage et Foresterie Tropicale (LEPAFORT), Institut Facultaire des Sciences Agronomiques de Yangambi (IFA-Yangambi), Kisangani P.O. Box 1232, Democratic Republic of the Congo; menikop@ifa-yangambi.org
4 Faculté d'Architecture, Université de Lubumbashi, Lubumbashi P.O. Box 1825, Democratic Republic of the Congo
5 Unité Ecologie, Restauration Ecologique et Paysage, Faculté des Sciences Agronomiques, Université de Lubumbashi, Lubumbashi P.O. Box 1825, Democratic Republic of the Congo; sikuzaniu@unilu.ac.cd
* Correspondence: lea.mukubu@student.uliege.be (L.M.P.); j.bogaert@uliege.be (J.B.); Tel.: +243-8548-17119 (L.M.P.)

Abstract: Biodiversity conservation is a key factor in meeting sustainable development goals. This is even more important in cities, where green spaces are becoming increasingly scarce. This study analyzes Kinshasa's proliferating ornamental plant nurseries, known as informal horticultural sites (IHSs). The analysis focused on characterizing the profile of horticulturists, their production conditions, and the ornamental species produced. A total of 15 IHSs were sampled using the "snowball" technique, and 178 horticulturists were surveyed. Based on the socio-professional profile of the horticulturists, five groups of IHS are distinguished after a hierarchical clustering of principal components (HCPC). We found that IHSs exclusively employed men, most of whom were new to the trade, from all levels of education, and most of whom ranged from 19 to 45 years old. Production conditions are relatively similar from one site to another. However, all IHSs are characterized by permanent land insecurity, the use of phytosanitary products, plant-conditioning methods that are not very diversified and calibrated to growers' investment capacities, and diversified seed acquisition methods. A total of 139 ornamental species, most of them exotic, were identified. Of these, 37% are phanerophytes, and 24% are considered potentially invasive. We suggest ways of professionalizing the activity and protecting the urban environment.

Keywords: urban horticulture; ornamental plants; ornamental woody plants; biodiversity conservation; urban environment; urban planning; invasive species

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1. Introduction

The recent strong urbanization underway worldwide is attracting all attention, particularly in terms of urban resilience strategies and practices [1–3]. It is indeed recognized that urbanization profoundly affects biodiversity, ecosystem processes and services, and climate and environmental quality [4]. It is, therefore, useful to study and control all urban practices, whether or not they are detrimental to biodiversity [5,6]. These include ornamental horticultural practices, which have so far received little attention in African cities [7].

The lack of attention paid to ornamental horticulture in African cities is because, when it comes to urban planning, the importance of aesthetics is often underestimated, and the link between quality of life, social progress, and other elements of well-being is

underdeveloped [8]. In addition, pervasive poverty forces populations to make choices oriented primarily toward food and economic security [9]. As a result, urban populations increasingly prefer to preserve edible rather than ornamental species in their living space [7,9].

In this trend towards the simplification/homogenization of urban ecosystems through choices made by households, a probable loss of diversity in ornamental plant species is to be feared in the medium term [10]. Yet, these species are necessary not only for the balance of environments but also for numerous industrial productions such as essential oils [11–13].

The growing disinterest in the cultural and aesthetic value of nature is what Occhiuto [14] refers to in part as the "abstraction of the Man-Nature relationship". This is clearly evident in Kinshasa, the capital of the Democratic Republic of Congo (DRC). Once known as "Kin-the-beautiful", the city of Kinshasa is now described as "Kin-the-trash" [15,16]. In fact, in colonial times, Kinshasa was composed, at least in its urban part, of beautiful landscapes of squares, hedges of ornamental plants, gardens, flowerbeds, and traffic arteries embellished with ornamental species [16]. It should be noted that, at this time, ornamental horticulture was of great importance in the country, as demonstrated by the creation during the same period of trial gardens (e.g., Kisantu in Kongo-Central and Eala in Mbandaka) for tropical ornamental plants of economic interest, in order to acclimatize and disperse them throughout the country [17]. This enthusiasm for floriculture, which was accompanied by the creation of several horticultural enterprises, unfortunately gradually died out after political independence in 1960 [18]. Yet, given the DRC's wealth of ornamental plants, which grow and develop spontaneously, maintaining the colonial-era enthusiasm for floriculture could have helped generate an important local economic sector, but also one for export, as is the case in Kenya [19] and India [20].

Fortunately, in the city of Kinshasa, ornamental plant nurseries have proliferated along traffic arteries for several decades, which are considered in this study as "informal horticultural sites" (IHS) [9,21].

This activity, which is increasingly attracting large numbers of Kinshasa residents, represents not only a phytodiversity market and a major mobilization of exotic and indigenous biodiversity but also a renewed interest in amenity species in the city's (peri-)urban areas. This sector, which is developing informally in Kinshasa, is poorly understood in a number of respects, such as the people involved, the benefits derived, the species exploited, seed acquisition methods, production conditions, and the risks of biological invasion [22,23].

It is, therefore, important to fill this gap to better control the disbursement of species, limit biological invasions, and better guide strategies for the conservation of peri-urban phytodiversity. Thus, the present study aims to provide a better understanding of this phenomenon of IHS proliferation in Kinshasa through the following three questions: (i) What is the profile of the producers engaged in the activity? (ii) Under what conditions do they ensure the production of ornamental plants in the different sites? (iii) What ornamental species do they produce; what is their diversity in terms of life form, their invasive status, and their conservation status? Studies on this ornamental horticulture activity in towns in Togo [24] and Quebec [25] show that it is the preserve of young people, often trained on the job, and that the species produced are largely of foreign origin. On this basis, we approach the present diagnostic analysis of IHSs in Kinshasa under the assumptions that (i) they employ mostly young people of all levels of education and improvised in the trade; (ii) their production conditions (access to production space, acquisition of seeds, use of phytosanitary products, conditioning of plants, and the existence of any support) are similar from one site to another; and (iii) the species produced are mostly exotic and include a threatened conservation status and potentially invasive species and are mostly phanerophytes.

2. Materials and Methods

2.1. Study Area

The study was carried out in the city province of Kinshasa (VPK), located southwest of the DRC, precisely to the south of the Malebo Pool, a widening of the Congo River (Figure 1). The VPK covers an area of 9965 km^2 and is administratively subdivided into 24 municipalities, 15 of which are urban, 4 peri-urban, and 5 rural according to their morphological building criteria [26]. The city site is structured into two morphological units: the "lower city" on the plain at an altitude of almost 300 m, covering 200 km^2, and the "upper city" on the hills rising to an altitude of 600 m, covering 240 km^2 [16]. The lower town concentrates the major arteries and roads that structure the city, as it includes the urban center, notably the municipality of Gombe. This is where we find informal horticultural sites (IHSs) set up along the roadsides. The upper town, on the other hand, is home to the majority of informal settlements without adequate roads. The climate of the VPK is tropical humid AW4 according to the Köppen– Geiger classification [27].

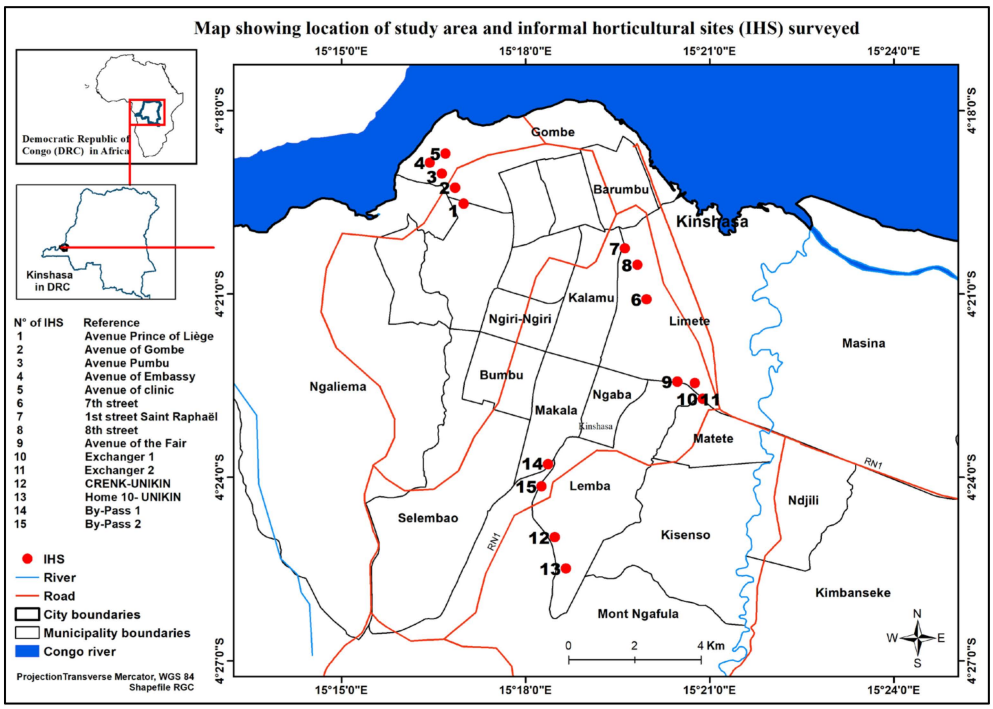

Figure 1. Location of study area and informal horticultural sites surveyed in the city of Kinshasa. Horticultural sites are represented by red points.

It is characterized by two seasons, one rainy (October to May, with a short interruption from late December to mid-February) and the other dry (June to September). The average annual rainfall is around 1430 mm [28]. The natural vegetation of the Kinshasa region was probably composed of dense forests, savannahs, and semi-aquatic and aquatic formations in the valleys and around the Malebo mare [29] and has been largely replaced by grassy savannahs and fruit trees concentrated in inhabited plots, particularly in the peri-urban zone [30].

The VPK has over 17 million inhabitants, the majority of whom are young, with an age structure comprising 48.3% aged 0 to 14, 49.4% aged 15 to 64, and 2.3% over 65 [30]. In 2005, the VPK had an incidence of poverty of 41.6%, with gender and level of education of the head of household as explanatory factors. It has a low employment rate (42.3%) compared with the national average (60.2%) and a high level of underemployment, which concerns 53.1% of the employed. The latter are generally engaged in the informal sector, which is the main provider of jobs in Kinshasa (65.6% of jobs and 89.5% of Kinshasa household income), according to SOSAK [30].

2.2. Sampling and Data Collection

A total of 15 informal horticultural sites (IHSs) were sampled (Figure 1), and we conducted the surveys using a technique known as "snowball sampling" [31]. This is a form of sampling based on the tracing of social ties, whereby individuals in the initial sample are asked to identify acquaintances, who are then asked to identify acquaintances, and so on, until a sufficient number of samples have been obtained to be exploited. In this study, we began the surveys by interviewing individuals by SHI as close as possible to the University of Kinshasa (UNIKIN) campus. Sampling was stopped when the number and list of ornamental species reached saturation.

This procedure yielded a total of 178 respondents. The use of this sampling method is justified by the lack of statistical data on the distribution of IHSs in the city.

The main drawback of this method is the bias generated by the relatively informal process of sample constitution. While it is, therefore, difficult to produce unbiased estimators for the characteristics of the population itself, it is nevertheless possible to make inferences about the parameters of the network of relationships [32]. This is precisely the aim of the present study, which seeks primarily to gain a better understanding of the structure of the horticulturists' network. The data collected on the species produced were confined to species listing, grower characteristics, and production conditions. Due to their sensitivity, economic and financial data were not addressed. It is important that other, more specific studies with an adapted approach address these aspects for a complete understanding of the related challenges.

Three categories of data were collected, covering the period from October 2022 to July 2023. The first category concerns the characterization of the socio-professional profile of workers in the various IHSs. This includes workers' gender (male or female), employment status (employer or employee), marital status (married, single, or other), age group following the city's age pyramid (under 18, 19–25, 26–35, 36–45, 46–55, and over 56), level of education (no education, primary, secondary, and university), retraining and/or training related to the nursery trade (apprenticeship or improvisation), whether or not they had another activity, and length of time in the trade (years of experience in the trade: less than 2 years, 3–5, 6–8, 9–12, and more than 12 years) and other secondary activities. The second category of data focused on the conditions of production of IHSs, notably the mode of acquisition of production space (by tacit or formal contract), the existence or not of taxation (annual tax or no tax), the mode of acquisition of seeds (by purchase, by picking, or by multiplication), the way seedlings are packaged (in plastic bags, hard plastic pots, paper bags, or concrete pots), whether or not phytosanitary products are used (herbicide, fungicide, and insecticide), whether or not they benefit from any form of support (bank loan, government fund, technical and financial support from non-governmental organizations, or private funding), and whether or not they belong to a professional association. The last category of data relates to the list of ornamental species produced, their origin, life forms, invasive status, and their conservation status. The definition of an ornamental plant or species is still a matter of debate [33]. We agree to adopt the widely accepted definition according to which an ornamental plant is a plant cultivated for its ornamental qualities rather than for its nutritional or industrial value. Such a definition distinguishes ornamental species from fruit, medicinal, and vegetable species [11].

2.3. Data Analysis

To test our hypothesis concerning the socio-professional profile of IHSs, we subjected the corresponding data (Table 1) to hierarchical clustering on principal components (HCPC) consisting of a hierarchical ascending classification following multiple correspondence analysis in order to group IHSs as similarly as possible. The analysis was carried out using R software (https://www.r-project.org/, accessed on 20 July 2023) and the FactoMineR package [34].

Table 1. Socio-professional characteristics of the nursery workers used in the study.

N°	Socio-Professional Characteristics	Meaning	Categories
1	**Gender**	Sex of respondent	Male Female
2	**Work status**	The status with which a person works on a site: as a plant owner working on his own account (Employer) or as working on behalf of another person (Employee)	Employer Employee
3	**Civil status**	Marital status	Married Singe
4	**Age group**	The group by age since birth	<18 years 19–25 years 26–35 years 36–45 years 46–55 years >56 years
5	**Education level**	The level of education achieved	No education Primary Secondary University
6	**Nursery trade**	The horticultural apprenticeship route: formal learning (Learned) or improvised learning (Improvised)	Learned Improvised
7	**Other income sources**	Another income-generating activity	No Yes
8	**Length of service**	Seniority or number of years in the horticultural business	<2 years 3–5 years 6–8 years 9–12 years >12 years

This approach makes it possible to account for characteristics common to different groups of IHS. We then performed a Fisher's exact test [35] on each of the production condition parameters to see whether the distribution of horticulturists in the different IHS groups formed is random. Such a procedure enables us to verify our hypothesis of the similarity of production conditions between the IHSs, depending on the number of recognized parameters linked to the distribution into IHS groups carried out. With regard to the species inventoried, we first checked their names, then determined their family and origin (exotic or indigenous) using available documents [36,37] and, in addition, online resources, notably the "African Plants Database", "International Plant Names Index (IPNI)", and "The Plant List" websites. The data thus generated enabled us to determine the relative proportions of genera, families, and origins of species in order to highlight any predominance.

The life forms of the plant species inventoried were established according to the definitions of Raunkiaer [38], which take into account the position of the buds, the type of unfavorable climate, and the size of the individual. Only the main categories were used: therophytes (Th), hemicryptophytes (Hem), geophytes (Ge), chamephytes (Ch), epiphytes (Epi), and phanerophytes (Ph). To determine the invasiveness of plant species, the Global Invasive Species Database [39] was consulted. The species conservation status was analyzed using the International Union for Conservation of Nature Red List database [40]. The observed statuses are extinct (EX), extinct in the wild (EW), critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC), data deficient (DD), and not evaluated (NE).

3. Results

3.1. Socio-Professional Profile of Horticulturists

Most informal horticultural sites (IHSs) are made up of groups of people, each of whom owns a batch of plants. The results of a multivariate analysis based on numerical classification applied to the socio-professional characteristics of IHSs enable us to group them into five relatively homogeneous groups (Figure 2).

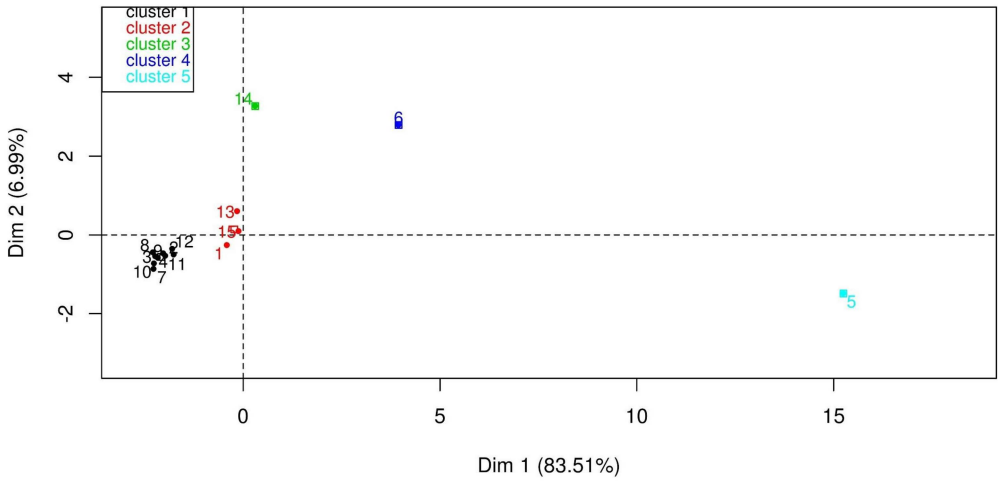

Figure 2. Result of the hierarchical classification of the principal components of the informal horticultural sites on the basis of the parameters of the socio-professional profile of the horticulturists (gender, work status, marital status, age, education level, way of learning the nursery trade, holding another activity, and length of service). Sites represented by their number are ordered according to their coordinates on the first component, which summarizes 83.51% of the information. Five groups are distinguished.

Group I comprises nine sites (sites 2; 3; 4; 7; 8; 9; 10; 11; and 12), Group II three sites (sites 1; 13; and 15), Group III site 14, Group IV site 6, and Group V site 5. Table 2 shows the socio-professional profile associated with each of these groups.

Group I corresponds to sites where certain socio-professional parameters have low values: an average of 2 employers and 0 employees, an average of 1 single person, individuals in the 19 to 25 and 26 to 35 age brackets with no formal education, workers who have actually learned the trade and those who have improvised, workers with or without horticultural activity and with reduced seniority (<2 years and 3–5 years) in the trade.

Group II is characterized by sites whose socio-professional parameters match those of the average of all sites. This is the group of sites with average socio-professional characteristics, i.e., 8 ± 12 employers and 4 ± 8 employees. Group III is made up of sites with a very low number of non-educated people. These sites have the same values as the average site for all other socio-professional parameters. As with the previous group, Group IV is made up of sites with the same values as the average site for all socio-professional parameters, except for the number of significantly older adults (>56 years), which is higher than the average. Group V represents sites where the socio-professional parameters have much higher values than the average. These are sites with a large number of workers in their fifties.

Apart from these differences between the groups of sites identified, we note that they are made up exclusively of males, with individuals of varied but young age brackets (between 19 and 45) and of equally varied levels of education and seniority in the trade. They are largely untrained in the trade; in other words, most of them have not undergone any formal training in the nursery trade (Table 2).

Table 2. Socio-professional characteristics, according to the correlation test, associated with the different groups of informal horticultural sites (IHSs) formed after hierarchical clustering on principal components (HCPC) applied to a sample of 15 IHSs corresponding to 178 horticulturists. The values in the table are the absolute average numbers of horticulturists for each characteristic of the sites making up the corresponding group.

Socio-Professional Characteristics		Gr Medium	Gr I (n_{ish} = 9)	Gr II (n_{ish} = 3)	Gr III (n_{ish} = 1)	Gr IV (n_{ish} = 1)	Gr V (n_{ish} = 1)
Gender distribution of horticulturists	Male	-	3	10	30	12	80
	Female	-	0	0	0	0	0
Work status	Employer	8	2 *	8	20	6	50 ***
	Employee	4	0 *	2	10	6	30 ***
Civil status	Married	7	2	4	18	5	50 ***
	Single	5	1 *	6	12	7	30 ***
Age group	<18 years	0	0	0	0 ***	2	0
	19–25 years	3	1 *	2	8	3	19 ***
	26–35 years	3	1 *	4	6	6	17 ***
	36–45 years	4	1	4	8	0	33 ***
	46–55 years	1	0	1	4	0	11 ***
	>56 years	0	0	0	4	1 ***	0
Education level	No education	3	0 **	3	8	7	16 ***
	Primary	3	1	2	10	1	20 ***
	Secondary	3	1	4	4	2	22 ***
	University	3	0	1	8	2	22 ***
Nursery trade	Learned	2	0 **	3	5	4	10 ***
	Improvised	10	2 *	8	25	8	70 ***
Other income sources	No	9	2 *	6	30	6	61 ***
	Yes	3	1 *	4	0	6	19 ***
Length of service	<2 years	2	1 **	4	5	3	10 ***
	3–5 years	3	1 **	3	10	6	15 ***
	6–8 years	4	1	2	10	2	30 ***
	9–12 years	2	0	1	5	1	15 ***
	>12 years	1	0	0	0	0	10 ***

Gr I = group number I; **Gr medium** = group representing the average characteristics of an IHS based on data from the 15 IHSs and the total of 178 horticulturists surveyed; $\mathbf{n_{ihs}}$ = number of informal horticultural sites making up the group after HCPC analysis. * = significant at 5% level; ** = significant at 1% level and *** = significant at 0.1% level. The existence of a significant link between a group and a modality of a variable identifies the main characteristics that define the socio-professional profile of horticulturists in the corresponding group and that also distinguish it from other groups.

3.2. Production Conditions for Horticulturalists

The results of the applied ANOVA indicate that the production area occupied by each horticulturist is not significantly different between the IHS groups identified ($F \approx 1.58$; *p*-value > 5%). The average area of individual production space obtained is 33 ± 4 m^2 with a relatively high coefficient of variation (CV) of 61%, suggesting the wide variation that exists between production areas.

Table 3 also shows that the groups of sites show statistically significant differences for seven of the twelve characteristics of production conditions considered. These are the mode of acquisition of the production space, the existence of taxation, the use of paper bags or hard plastic plugs or concrete pots for packaging seedlings, the use of phytosanitary products, and the organization into associations.

Table 3. Characteristics of the production conditions of the different groups of informal horticultural sites formed after hierarchical classification on principal components. Gr = group; n = total number of horticultural employers in the corresponding group; *** = significant at the 0.1% threshold according to Fisher's exact test, and ns = not significant according to the same test.

Characteristics of Production Conditions		Proportions by Horticultural Site Group (%)					*p*-Value
		Gr I n = 21	Gr II n = 25	Gr III n = 20	Gr IV n = 6	Gr V n = 50	
How to acquire production space	Tacit contract	43	84	30	33	0	***
	Formal contract	57	16	70	67	100	
Existence of taxation	Annual fee	48	16	70	67	100	***
	No tax	52	84	30	33	0	
Seed acquisition mode							
Second-hand purchase	Yes	100	100	100	100	100	ns
	No	0	0	0	0	0	
Picking	Yes	43	56	40	17	60	ns
	No	57	44	60	83	40	
Multiplication	Yes	100	100	100	100	100	ns
	No	0	0	0	0	0	
Seedling packaging method							
Plastic bag	Yes	100	100	100	100	100	ns
	No	0	0	0	0	0	
Paper bag	Yes	14	40	0	33	60	***
	No	86	60	100	67	40	
Hard plastic pot	Yes	10	4	25	33	50	***
	No	90	96	75	67	50	
Concrete pot	Yes	24	0	0	0	0	***
	No	76	100	100	100	100	
Use of phytosanitary products	Yes	81	56	100	67	100	***
	No	19	44	0	33	0	
Technical or financial support, bank loan or government fund	Yes	0	0	0	0	0	ns
	No	100	100	100	100	100	
Association organization	Yes	0	0	50	0	100	***
	No	100	100	50	100	0	

The mode of acquisition of production space by formal contract is the predominant one for all groups, except for Group II, where it is rather the tacit contract. Consequently, the non-existence of taxation for production space is more remarkable for Group II.

With regard to plant packaging (Figure 3 and Table 3), all groups except Group III use paper bags, with Group V being the most abundant (60% of growers). Similarly, all groups use hard plastic pots, with Group V using the most (50% of growers). On the other hand, only Group I uses concrete pots, and only to a small extent (24% of growers). We also note that a large proportion of growers in the various groups use plant protection products (herbicides to control weeds, fungicides to control fungi, and insecticides to

control insects). In particular, all growers (100%) in Groups III and V use them and are organized in associations in proportions of 50% and 100%, respectively.

Figure 3. Illustration of plant-packaging methods on informal horticultural sites in Kinshasa. (**a**,**b**)—variety of sizes and colors of plastic bags used; (**c**)—paper bags used; (**d**)—hard plastic pots commonly used; and (**e**)—concrete pots used.

With regard to the other five characteristics of production conditions, we note that for all horticultural sites, three modes of seed acquisition coexist: occasional purchase, picking, and multiplication. Likewise, all the sites use plastic bags indiscriminately to package seedlings, and none of them benefit from support from any structure.

3.3. Cultivated Species, Their Origin, Biological Type, and Invasive and Conservation Status

A total of 139 ornamental species in 119 genera and 62 families were inventoried at the sites surveyed (Table 4). The five most represented genera are *Begonia* (3%), *Acalypha* (2%), *Alternanthera* (2%), *Kalanchoe* (2%), and *Senna* (2%), with the remaining 144 genera accounting for 88%. Similarly, the 5 most abundant families are *Araceae* (9%), *Fabaceae* (6%), *Asteraceae* (6%), *Amaranthaceae* (5%), and *Euphorbiaceae* (4%), with the remaining 57 families accounting for 84%.

Table 4. List of ornamental species inventoried in informal horticultural sites (IHSs) in the city of Kinshasa and their associated characteristics: (i) origin of species (OR): autochthonous (Au), exotic (Ex), or uncertain (In); (ii) biological type (TB): theophytes (Th), hemicryptophytes (Hém), geophytes (Ge), chamephytes (Ch), epiphytes (Epi), and phanerophytes (Ph); (iii) invasive status (SI): not invasive (NI) or potentially invasive (PI); (iv) conservation status (CS): critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC), data deficient (DD), and not evaluated (NE).

Scientific Name	Family	OR	TB	SI	SC
Acalypha crenata Hochst. ex A. Rich.	Euphorbiaceae	Ex	Th	NI	LC
Acalypha hispida Burm. f.	Euphorbiaceae	Ex	Ph	NI	LC
Acalypha wilkesiana Müll. Arg.	Euphorbiaceae	Ex	Ph	NI	LC
Acanthus montanus T. Anderson	Acanthaceae	Au	Ch	NI	LC
Aechmea bracteata (Sw.) Griseb.	Bromeliaceae	Ex	Epi	NI	LC
Agapanthus africanus (L.) Hoffmanns	Amaryllidaceae	Ex	Gé	PI	LC
Agave americana L.	Agavaceae	Ex	Ph	PI	LC
Aglaonema pictum (Roxb.) Kunth	Araceae	Ex	Gé	NI	LC
Albizia chinensis (Osbeck) Merr.	Fabaceae	Ex	Ph	PI	NE
Alcea rosea L.	Malvaceae	Ex	Hem	NI	LC
Allamanda cathartica L.	Apocynaceae	Ex	Ph	NI	LC
Alocasia macrorrhizos (L.) G. Don.	Araceae	Ex	Gé	PI	LC
Alocasia portei Schott	Araceae	Ex	Gé	PI	LC
Aloe congolensis De Wild. and T. Durand	Liliaceae	Au	Gé	PI	LC
Aloe vera (L.) Burm. f.	Liliaceae	In	Gé	PI	LC
Alpinia vittata W. Bull	Zingiberaceae	Ex	Gé	PI	LC
Alternanthera amoena (Lem.) Voss	Amaranthaceae	Ex	Hem	NI	NE
Alternanthera bettzickiana (Regel) G. Nicholson	Amaranthaceae	Ex	Hem	NI	NE
Alternanthera sessilis (L.) R. Br. ex DC.	Amaranthaceae	Ex	Hem	PI	LC
Alternanthera tenella Colla	Amaranthaceae	Ex	Hem	NI	NE
Ananas comosus (L.) Merr.	Bromeliaceae	Ex	Epi	NI	AT
Angelonia grandiflora C. Morr.	Scrophulariaceae	Ex	Hem	PI	NE
Anthurium andraeanum Linden ex André	Araceae	Ex	Gé	NI	NE
Anthurium sherzerianum Schott	Araceae	Ex	Gé	NI	NE
Antigonos leptopus H. and A.	Polygonaceae	Ex	Ph	PI	LC
Anubias hastifolia Engler	Araceae	Au	Gé	NI	LC
Araucaria excelsa (Lamb.) R. Br.	Araucariaceae	Ex	Ph	NI	LC
Araucaria heterophylla (Salisb.) Franco	Araucariaceae	Ex	Ph	NI	VU
Areca cathecu L.	Arecaceae	Ex	Ph	PI	DD
Arenga pinnata (Wurmb) Merr.	Arecaceae	Ex	Ph	NI	NE
Argemone mexicana L.	Papaveraceae	Ex	Th	PI	NT
Arisaema urashima H. Hara) H. Ohashi and J. Murata	Araceae	Ex	Gé	NI	NE
Aristolochia elegans Mast.	Aristolochiaceae	Ex	Gé	PI	LC
Artocarpus incisa (Parkinson) Fosberg	Moraceae	Ex	Ph	NI	NE
Arundo donax L.	Poaceae	Ex	Hem	PI	LC
Asparagus plumosus Baker	Liliaceae	Ex	Gé	PI	LC
Asplenium nidus L.	Aspleniaceae	Au	Hem	NI	LC
Aster amellus L.	Asteraceae	Ex	Hem	NI	LC
Ataenidia conferta (Benth.) Milne-Redh.	Marantaceae	Ex	Ph	NI	NE
Azadirachta indica A. Juss	Meliaceae	Ex	Ph	PI	LC
Bauhinia purpurea L.	Fabaceae	Ex	Hem	NI	LC
Bauhinia tomentosa L.	Fabaceae	Ex	Hem	NI	LC
Begonia eminii Warb.	Begoniaceae	Au	Epi	NI	AT

Table 4. *Cont.*

Scientific Name	Family	OR	TB	SI	SC
Begonia glabra Aubl.	Begoniaceae	Ex	Epi	NI	VU
Begonia rex Putz.	Begoniaceae	Ex	Epi	NI	LC
Begonia semperflorens hort.	Begoniaceae	Ex	Epi	NI	LC
Belamcanda chinensis L.	Iridaceae	Ex	Gé	NI	NE
Bellucia grossularioides (L.) Triana	Melastomataceae	Ex	Ph	NI	LC
Berlinia grandiflora (Vahl) Hutch. and Dalziel	Fabaceae	Au	Ph	NI	LC
Bidens sulphurea (Cav.) Sch. Bip.	Asteraceae	Ex	Th	NI	LC
Bignonia venusta Ker Gawl.	Bignoniaceae	Ex	Ph	NI	LC
Biophytum Zenkeri Guillaumin	Oxalidaceae	Au	Ph	NI	VU
Bixa orellana L.	Bixaceae	Ex	Ph	NI	LC
Borassus aethiopum Mart.	Arecaceae	Au	Ph	NI	LC
Bougainvillea glabra Choisy	Nyctaginaceae	Ex	Ph	NI	LC
Bougainvillea spectabilis Willd.	Nyctaginaceae	Ex	Ph	NI	NE
Breynia disticha J. R. Forst. and G. Forst.	Phyllanthaceae	Ex	Ph	PI	LC
Caesalpinia pulcherrima (L.) Sw.	Fabaceae	Ex	Ph	NI	LC
Caladium bicolore (Aiton) Vent.	Araceae	Ex	Gé	PI	CR
Calathea ornata (Linden) Körn.	Marantaceae	Ex	Hem	NI	NE
Calathea zebrina (Sims) Lindl.	Marantaceae	Ex	Hem	NI	NE
Callistephus chinensis (L.) Nees	Asteraceae	Ex	Th	NI	LC
Camellia japonica L.	Theaceae	Ex	Ph	NI	LC
Cananga odorata (Lam.) Hook. f. and Thomson	Annonaceae	Ex	Ph	NI	LC
Canna iridiflora Ruiz and Pav.	Cannaceae	Ex	Gé	NI	NE
Carludovica atrovirens H. Wendl.	Cyclanthaceae	Ex	Epi	NI	LC
Carludovica palmata Ruiz and Pav.	Cyclanthaceae	Ex	Epi	NI	LC
Catharanthus roseus (L.) G. Don	Apocynaceae	Ex	Hem	NI	NE
Celosia argentea L.	Amaranthaceae	Ex	Th	PI	LC
Celosia cristata L.	Amaranthaceae	Ex	Th	PI	LC
Chlorophytum comosum (Thunb.) Jacques	Asparagaceae	Ex	Hem	NI	LC
Cissus discolor Blume	Vitaceae	Ex	Ph	NI	NE
Codieum variegatum (L.) A. Juss.	Euphorbiaceae	Ex	Hem	NI	LC
Cosmos bipinnatus Cav.	Asteraceae	Ex	Th	NI	NE
Costus sanguineus Donnell Smith	Costaceae	Ex	Hem	NI	AT
Crinum americanum L.	Amaryllidaceae	Ex	Gé	NI	LC
Curculigo latifolia Dryand. ex W. T. Aiton	Hypoxidaceae	Ex	Gé	NI	LC
Cycas revoluta Thunb.	Cycadaceae	Ex	Ph	NI	LC
Cyclanthus bipartitus Poit. ex A. Rich.	Cyclanthaceae	Ex	Gé	NI	NE
Dahlia coccinea Cav.	Asteraceae	Ex	Hem	NI	NT
Dianthus caryophyllus L.	Caryophyllaceae	Ex	Hem	NI	LC
Dieffenbachia amoena hort. ex Gentil	Araceae	Ex	Ch	NI	DD
Duranta repens L.	Verbenaceae	Ex	Ph	NI	NE
Encephalartos cycadifoluis Jacquin	Cycadaceae	Ex	Ph	NI	LC
Episcia bicolor Hook.	Gesneriaceae	Ex	Hem	NI	NE
Eremochloa ophiuroides (Munro) Hack.	Poaceae	Ex	Hem	PI	NE
Euphorbia pulcherrima Willd. ex Klotzsch	Euphorbiaceae	Ex	Ph	NI	LC
Ficus repens auct.	Moraceae	Ex	Hem	NI	NE
Fittonia gigantea Linden	Acanthaceae	Ex	Hem	NI	NE
Galphimia gracilis Bartl.	Malpighiaceae	Ex	Ph	NI	NE
Gardenia jovis-tonantis (Welw.) Hiern	Rubiaceae	Au	Ph	NI	LC
Gomphrena globulosa L.	Amaranthaceae	Ex	Ch	NI	NE
Haemanthus multiflorus Martyn	Amaryllidaceae	Au	Gé	NI	LC

Table 4. *Cont.*

Scientific Name	Family	OR	TB	SI	SC
Helianthus annus L.	Asteraceae	Ex	Gé	NI	LC
Hibiscus rosa-sinensis L.	Malvaceae	In	Ph	NI	LC
Hippeastrum equestre (Aiton) Herb.	Amaryllidaceae	Ex	Gé	NI	NE
Hydranga macrophylla (Thunb.) Ser.	Hydrangeaceae	Ex	Ph	NI	NE
Impatiens balsamina L.	Balsaminaceae	Ex	Th	NI	LC
Ixora coccinea L.	Rubiaceae	Ex	Hem	NI	LC
Jasmin officinale L.	Oleaceae	Ex	Ph	NI	NE
Jatropha curcas L.	Euphorbiaceae	Ex	Ph	NI	LC
Kalanchoe delagoensis Eckl. and Zeyh.	Crassulaceae	Ex	Hem	PI	NE
Kalanchoe pinnata (Lam.) Pers.	Crassulaceae	Ex	Hem	PI	NE
Kalanchoe tomentosa Baker	Crassulaceae	Ex	Hem	PI	NE
Lantana camara L.	Verbenaceae	Ex	Ph	PI	NE
Lonicera longiflora (Lindl.) DC.	Caprifoliaceae	Ex	Ph	NI	NE
Malpighia coccigera L.	Malpighiaceae	Ex	Ph	NI	NE
Maranta bicolor Ker Gawl.	Marantaceae	Ex	Hem	NI	NE
Mimoza asperata L.	Fabaceae	Ex	Ph	PI	LC
Mirabilis Jalapa L.	Nyctaginaceae	Ex	Hem	NI	LC
Monstera deliciosa Liebm.	Araceae	Ex	Ch	NI	NE
Nephrolepis acuminata (Willd.) C. Presl	Polypodiaceae	Ex	Ch	NI	NE
Nerium oleander L.	Apocynaceae	Ex	Ph	NI	LC
Pandanus furcatus Roxb.	Pandanaceae	Ex	Ph	NI	AT
Pelargonium carpitatum (L.) L'Hér.	Geraniaceae	Ex	Hem	NI	NE
Phlox drummondii Hook.	Portulacaceae	Ex	Th	NI	AT
Phyllanthus nivosus W. Bull	Phyllanthaceae	Ex	Ph	NI	LC
Pilea muscosa Lindl.	Uriacaceae	Ex	Hem	NI	LC
Plumbago auriculata Lamarck	Plumbaginaceae	Ex	Ph	NI	NE
Polianthes tuberosa L.	Asparagaceae	Ex	Gé	NI	NE
Portulaca grandiflora Hook.	Portulacaceae	Ex	Ch	NI	LC
Ravenala madagascarensis Sonn.	Strelitziaceae	Ex	Ph	NI	LC
Rhoeo discolor (L'Hér.) Hance ex Walp.	Commelinaceae	Ex	Hem	NI	DD
Rosa simensis Hibiscus rosa-sinensis L.	Malvaceae	Ex	Ph	NI	NE
Roystonia regia (Kunth) O. F. Cook	Araceae	Ex	Ph	NI	LC
Salvia splendens Sellow ex Schult.	Labieae	Ex	Hem	NI	NE
Sanchezia nobilis Hook. f.	Acanthaceae	Ex	Ph	NI	NE
Sansaviera trifasciata Prain	Asparagaceae	Au	Gé	PI	NE
Selaginella apus (L.) Spring	Selaginellaceae	Ex	Hem	NI	LC
Senna alata (L.) Roxb.	Fabaceae	Ex	Ph	PI	LC
Senna occidentalis (L.) Link	Fabaceae	Ex	Ph	PI	LC
Senna spectabilis (DC.) H. S. Irwin and Barneby	Fabaceae	Ex	Ph	PI	LC
Setcreasea purpurea Boom	Commelinaceae	Ex	Hem	NI	NE
Spathiphyllum blandum Schott	Araceae	Ex	Hem	NI	NE
Syngonium auritum (L.) Schott	Araceae	Ex	Ph	PI	NE
Tagette erecta L.	Asteraceae	Ex	Th	NI	NE
Tithonia tagetiflora Desf.	Asteraceae	Ex	Hem	NI	LC
Torenia fournieri Linden ex E. Fourn.	Scrophulariaceae	Ex	Th	PI	NE
Zinnia angustifolia Kunth	Asteraceae	Ex	Th	NI	NE

Furthermore, we note that the majority of ornamental species are exotic (91%), and only 8% are indigenous. Moreover, species of uncertain origin (1%) are likely to be foreign to the study area. A total of 106 species (76%) were quantified as non-invasive and 33 species (24%) as potentially invasive (Table 3).

The results of the life forms of the different ornamental species in the IHSs of the city of Kinshasa show a dominance of phanerophytes (37%), which are trees and shrubs but also woody lianas that can grow up to the cymes of the largest trees. Other life forms, notably hemicryptophytes, geophytes, therophytes, epiphytes, and chamephytes, account for 27%, 17%, 9%, 6%, and 4% of species recorded, respectively (Figure 4).

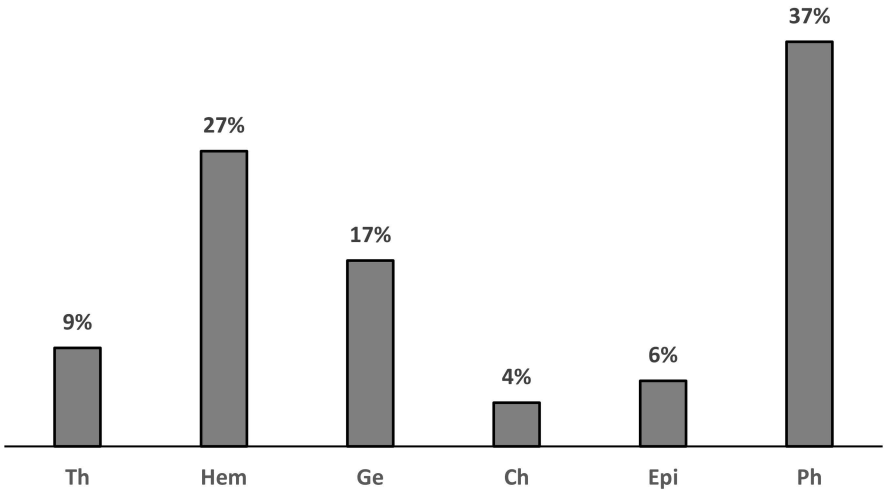

Figure 4. Distribution of the 139 species into life forms as defined by Raunkiaer [38]: thephytes (Th), hemicryptophytes (Hem), geophytes (Ge), chamephytes (Ch), epiphytes (Epi), and phanerophytes (Ph).

According to the IUCN Red List, of the 139 species listed, 1 (0.72%), *Caladium bicolore* (Aiton) Vent. is critically endangered (CR), 5 species (4%) are endangered (EN), *Ananas comosus* (L.) Merr, *Costus sanguineus* Donnell Smith, *Begonia eminii* Warb, *Pandanus furcatus* Roxb, *Phlox drummondii* Hook, 3 (2%) are vulnerable (VU), *Araucaria heterophylla* (Salisb.) Franco, *Begonia glabra* Aubl, *Biophytum Zenkeri* Guillaumin; 2 (1%) are near threatened (NT), *Dahlia coccinea* Cav. and *Argemone mexicana* L.; 3 (2%) are data deficient (DD); and 52 (37%) are not evaluated (NE). On the other hand, 73 species (53%) are in the LC category, i.e., of minor conservation concern (no threat) (Figure 5).

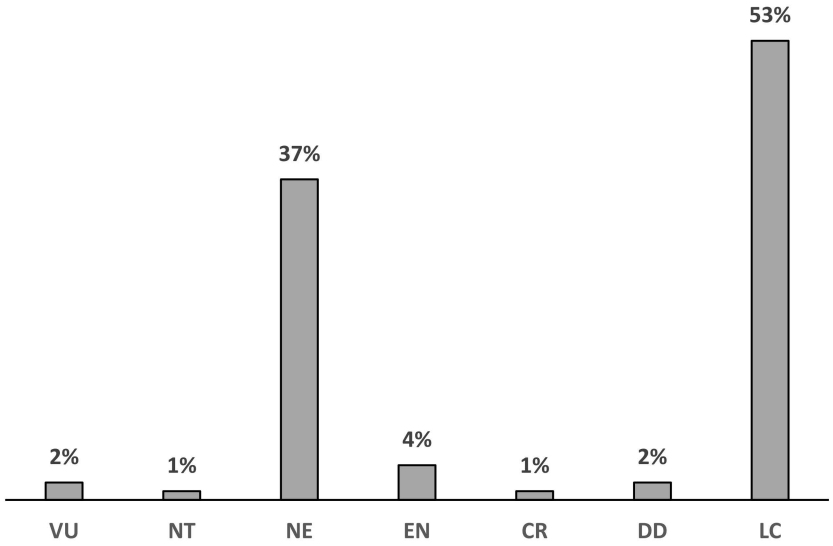

Figure 5. Proportion of the 139 species identified according to IUCN criteria in various sampled IHSs in the city of Kinshasa. Indices: critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC), data deficient (DD), not evaluated (NE). A total of 8% of species (11 species) are in threatened categories (CR, EN, VU, and NT).

4. Discussion

4.1. Contrasting Characteristics of Informal Horticultural Sites in Kinshasa: The Need for Horticulturists to Be Supervised

Five groups of informal horticultural sites (IHSs) are distinguished according to their socio-professional profile. This classification reflects the physical reality of the workers in

the different IHSs. Indeed, while some IHS sites, such as site 7 (1st street Saint Raphaël) in Group I, have few young or old workers, others, such as site 5 (Avenue of Clinic) in Group V, have an impressive number of workers. Such variation in IHS composition can be explained by their location in the city, not only in terms of the availability of production space but also the existence of potential demand in the surrounding area (Figure 6).

Figure 6. Illustration of informal horticultural sites in Kinshasa. (**a**)—the Avenue of Clinic site in the commune of Gombe. This site is home to up to fifty workers, whose plants stretch for almost a kilometer along the avenue. The parked vehicles are those of customers in the middle of buying plants. (**b**)—the site on the first street near Collège Saint Raphaël in the commune of Limete. This site has just two workers whose facilities are spread over a small area of just a few meters.

Furthermore, Kinshasa's IHSs employ a large number of people (a total workforce of 178 for 15 sites) compared with other cities where the same activity is developing, such as the cities of Atakpamé, Lomé, and Kpalimé in Togo, which in 2013 had a total of 179 workers for 55 sites [24]. This could be explained by the fact that Kinshasa is a more populous city with a high unemployment rate [41]. What is more, just as in these same Togolese cities, IHSs in Kinshasa employ mostly young people between the ages of 19 and 45, thus confirming our related hypothesis. However, Kinshasa's IHSs include all levels of education, but both employers and employees are, for the most part, improvised in the trade. The same observation has been made in cities in developed countries such as Quebec, in a report by the Institut québécois des ressources humaines en horticulture [25], which recommends the organization of training courses in horticulture and landscaping.

The activity of informal ornamental horticulture thus appears as a convincing example of the famous "débrouillardisme" or "mayele" (in Lingala, one of the vernacular languages) developed in Kinshasa to curb the poignant crises of unemployment and poverty [15]. It is, therefore, also, as the people of Kinshasa put it, an implementation of Article 15, a fictitious article of the Constitution that would stipulate: "débrouillez-vous pour vivre" [30].

We also note that, unlike other African cities such as Togo [13], ornamental horticulture is exclusively a male activity in Kinshasa. Indeed, although it can bring in income, ornamental horticulture is not directly linked to the daily life of the Kinshasa woman. Instead, she is preoccupied with and attracted to activities directly linked to the socio-economic life of the household, such as market gardening for vegetables, petty trading for basic necessities, and so on.

Seven out of the twelve production condition parameters showed significant differences between the different IHS groups (Table 2). Our hypothesis about the similarity of production conditions between the IHS sites is, therefore, partially invalidated. The production area of most sites is often located on the edge of busy thoroughfares and in front of a public structure (ministry, directorate, traffic circle, and other administrative services) or private structure (school, hotel, shop, and residence). Consequently, contracts for the

acquisition of these spaces are either tacit, based on oral or de facto authorization from the corresponding public or private authority, or formal, based on an occupancy-authorization document. Whatever the case, the mode of acquisition of production space remains precarious and maintains a permanent insecurity of land tenure in the activity, as also reported in Togo [13]. As some of the producers interviewed explained, they work under the constant threat of being evicted at any time by the owners of the public or private space they occupy. It was these repeated threats that prompted the growers on site 5 (Avenue of Clinic in the commune of Gombe) to organize themselves into an association and hire a lawyer to defend them.

In addition, we note that seeds and seedlings are obtained in a variety of ways (occasional purchase, collection, and multiplication) (Table 2). This allows the necessary dissemination of ornamental plant genetic resources. Nevertheless, in view of the risks of invasion strongly correlated with ornamental horticulture [23,42–44], the circulation of these plant genetic resources must not be prohibited but secured by alerts on potentially invasive species. A prime example, well known to the Congolese as "*Congo ya sika*", is the water hyacinth (*Eichhornia crassipes* (Martus) Solms In A. DC.). This species, originally from Brazil, was introduced into the Congo shortly before independence to decorate water features, from where it escaped to invade the Congo River [45]. There is, therefore, a need to provide support to growers, who to date have received no assistance whatsoever, probably due to their informal status. This support could include technical assistance on the proper use of phytosanitary products or alternative products to protect the urban environment and workers' health.

The latter are exposed to health risks as a result of coming into contact with a wide range of plant and chemical substances [46].

Variations in seedling conditioning methods (Table 2) can be explained via the associated investment costs. Packaging seedlings in concrete or hard plastic pots requires considerable investment. Plants packaged in this way are expensive and, therefore, difficult to sell on the market. As a result, some growers choose to produce certain types of packaging only to order. The range of packaging methods for registered seedlings is limited and excludes an important local market.

These include, for example, the market for wreaths for the many funeral ceremonies or *matanga* (in Lingala) and the market for bouquets of flowers for the many wedding ceremonies or *libala* (in Lingala) held in Kinshasa. These markets are currently being flooded by the plastics industry, and so appear to be a loss of earnings for producers, given a large number of *matanga* and *libala* events held in the city.

We noted a total number of 139 ornamental species produced in the 15 IHSs we visited. This number is still comparable to, but higher than, that recorded in the city of Dakar, i.e., 109 species in 59 stations [8], but by far low compared with the number of over 600 ornamental species reported by Radji et al. [47] in the cities of Lomé, Atakpamé, and Kpalimé in Togo. There are two main reasons for this difference. The first relates to the definition of the ornamental species under consideration. Radji et al. [47] considered a very broad definition of ornamental species, including known species cultivated primarily for their edibility but often found in private or public gardens, such as *mangifera indica* L. Nevertheless, as Allain [33] points out, the definition of a plant's ornamental status remains relative and variable in time and space, depending on changing needs and uses. The second reason relates to the inventory approach employed. Our inventory was limited to horticultural sites, whereas Radji et al. [47] extended it to parks and gardens. We note, however, that Kinshasa's IHSs maintain a sizeable market in phytobiodiversity. As reported elsewhere, such as in the cities of Togo [24], most of these species are exotic. Clearly, a major effort still needs to be made by all stakeholders to promote indigenous species.

Concerning the result on species' life forms, we noted the dominance of phanerophytes. The dominance of phanerophytes is reported in urban environments [8,48–50]. Phanerophytes are in high demand in cities, as they adapt better to the rather harsh climatic

and edaphic conditions of the city [51]. What is more, because of their size, they are able to provide shade in all seasons, a very important service in urban environments [52].

Furthermore, the presence of a significant number (33 species) of potentially invasive species confirms the Hu et al. [53] observation that ornamental horticulture is a major vector of invasive plants. This underlines the importance of controlling the circulation of plant species through the informal horticultural sites studied. These sites contribute to the reproduction/multiplication of species that are important from the point of view of biodiversity conservation. They are home to a significant number of moderately to highly threatened species.

4.2. Implications for Urban Biodiversity Conservation

This study highlights several implications for the conservation of phytobiodiversity and urban planning, namely, the professionalization of informal horticultural site managers, the introduction of monitoring of the circulation of potentially invasive species, and the promotion of indigenous species in urban landscaping.

The current rapid expansion of urban areas poses a major threat to urban biodiversity (loss of green spaces, reduction in pollinating insects, reduction in native species, etc.) and also generates extremely significant environmental impacts (flooding, air pollution, heat islands, degradation of ecosystem services, etc.). Increasing urbanization represents a fundamental challenge but also an opportunity to design cities that are livable, healthier, and more resilient (adapted to the effects of climate change) [54,55]. One way of achieving this is by planting native species in urban horticultural areas. Native plants play an essential role in maintaining biodiversity. There are several reasons for choosing native plants: they are an important source of food for local wildlife and an ideal habitat for insect populations, including birds, pollinators, butterflies, and other species. They are less demanding and adapt very easily to the effects of climate change. They also provide a number of ecosystem services, including climate regulation, water regulation, pollution reduction, and improved human well-being [54,55].

5. Conclusions

This study provides a diagnosis of the informal horticultural sites (IHS) that are proliferating in Kinshasa. Analysis of the socio-professional profile of these IHSs has enabled us to classify them into five groups. The IHSs employ exclusively men, most of whom are improvised in the trade, from all levels of education, and mostly in the 19 to 45 age brackets. We also note that IHSs offer employment or income to a significant number of people and, therefore, households.

Production conditions are relatively similar from one site to another. Nevertheless, the study reveals that IHS sites are characterized by permanent land tenure insecurity, the use of phytosanitary products and plant-conditioning methods that are not diversified and calibrated to growers' investment capacities.

Furthermore, thanks to the diversified ways in which growers acquire seeds, IHSs encourage the dissemination of ornamental plant genetic resources, which should be safeguarded by issuing warnings about species at risk. Our results also show that IHSs provide a significant market for phytobiodiversity, with at least 139 ornamental species, most of them exotic, including 33 identified as potentially invasive. It would be interesting to study in greater depth the links between the diversity of species bred at different sites and the relevant characteristics of horticulturalists.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

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