Asian Plant Research Journal

5(3): 45-64, 2020; Article no.APRJ.57418
ISSN: 2581-9992

Plant Genetic Resources Used as Packaging on the Mongata-Kinshasa-Kisantu Axis in the Democratic Republic of the Congo

Henri Kunzi Mbale[1*], Adeline Nkfutu Akadje[2], Alexis die-Ditomene Mayoni[2], Gédéon Ngiala Bongo[1], Michael Tshibangu Mukendi[1] and Félicien Luyeye Lukoki[1]

[1]Department of Biological Sciences, Faculty of Sciences, University of Kinshasa, Kinshasa, Democratic Republic of the Congo.
[2]Department of Environmental Sciences, Faculty of Sciences, University of Kinshasa, Kinshasa, Democratic Republic of the Congo.

Authors' contributions

This work was carried out in collaboration among all authors. Author HKM designed the study, conducted the fieldwork and wrote the protocol. Authors HKM and GNB wrote the first draft of the manuscript. Authors FLL, ANA and ADM managed the analyses of the study. Authors MTM and GNB managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/APRJ/2020/v5i330110
Editor(s):
(1) Dr. Msafiri Yusuph Mkonda, Sokoine University of Agriculture, Tanzania.
Reviewers:
(1) Syed Aneel Ahmad Gilani, Pakistan Museum of Natural History, Pakistan.
(2) Anuradha Agrawal, ICAR - National Bureau of Plant Genetic Resources, Pusa Campus, India.
(3) Noor Camellia Noor Alam, Malaysian Agricultural Research and Development Institute, Malaysia.
Complete Peer review History: http://www.sdiarticle4.com/review-history/57418

Original Research Article

Received 27 April 2020
Accepted 02 July 2020
Published 13 July 2020

ABSTRACT

The current relevance of Non-Timber Forest Products (NTFPs) as well as plant genetic resources (PGRs) for foresters and indigenous populations has prompted numerous initiatives in the last decade. In order to assess the environmental impact of the Plant Genetic Resources (PGRs) used as packaging, a survey was carried out on 64 respondents between April 2017 and March 2018 along the axes of Mongata-Kinshasa-Kisantu, in the Democratic Republic of the Congo. The findings showed that 16 PGRs were identified, namely: (*Lasimorpha senegalensis, Elaeis guineensis, Eremospatha haullevilleana, Eremospatha cabrae, Ectadiopsis oblongifolia, Cyperus papyrus, Hymenocardia acida, Musa spp., Saccharum officinarum, Triumfetta cordifolia, Urena lobata,*

**Corresponding author: E-mail: mbalehenri@yahoo.fr;*

Marantochloa congensis, Megaphrynium macrostachyum, Haumania liebrechtsiana, Sarcophrynium schweinfurthianum var . puberifilifolium, Thalia geniculata). They belong to 9 families, of which *(Araceae, Arecaceae; Apocynaceae; Cyperaceae; Phyllanthaceae; Musaceae; Poaceae; Malvaceae/Tiliodeae; Marantaceae*). Moreover, these resources constitute an additional source of income for households for their primary needs. While these resources are relatively threatened at their natural area if any sustainable management is not envisaged. These PGRs, after use, become organics wastes, which contribute both to insalubrity and to the visual as well as the olfactive pollution of public sites. At this rate of extraction for marketing and without a policy of supervision or support for predatory organizations, these plant resources are in danger of disappearing in the short term. The urgent need is to identify all these PGRs and to study their technical cultivation routes with a view to their domestication.

Keywords: Ethnobotanical survey; PGRs; packagings; Kisantu; Kinshasa; Mongata; DRC.

1. INTRODUCTION

Ecologists have been denouncing the waste of natural resources and making the world aware of the degradation of the global environment because of abusive economic models of forest exploitation since 1970. Following the applied Forest Code in the Democratic Republic of the Congo (DRC), the forest exploitation is the set of activities consisting precisely in the felling, processing and transport of wood or any other wood products, as well as the collection of other forest products for economic purposes [1].

The current relevance of Non-Timber Forest Products (NTFPs) as well as plant genetic resources (PGRs) for conservationists, foresters, development stakeholders and indigenous populations has prompted numerous initiatives in the last decade. The objective was to promote their sustainable use and commercialization as a means to improve the well-being of rural populations as well as conserve their ecosystems [2,3]. The term NTFPs encompasses all biological materials other than timber which are extracted from forests, other wooded land, and trees outside forests along with domesticated that include products used as food and food additives (edible nuts, mushrooms, grass-cutters, snails, fruits, herbs, spices and condiments, aromatic plants, game), fibres (used in construction, furniture, clothing, or utensils), resins, gums, and plant as well as animal products used for medicinal, cosmetic or cultural purpose for human use. NTFPs form an integral part of the livelihood strategy of rural communities in the tropics and continue to be an important component of household nutrition and health in Africa [4].

Since immemorial times, NTFPs have been an important part for the living of forest and savannah inhabitants through sustained exploitation. Furthermore, many forest resources serve as food for local populations and contribute to the diversification of their diet [5,6].

However, there is very little information on the species that are the subject of this trade and the consequence of the valorization of these products on the sustainable management of forest resources. It is therefore very important to investigate bottlenecks in the trade of NTFPs in large cities in order to establish an adequate policy for the management of NTFPs throughout the national territory [7]. These initiatives are rarely linked to studies on the biologically sustainable exploitation of PGRs used as packaging, and there is a lack of accurate information on the stock and abundance of these resources, their distribution and reproductive biology as well as the sustainability of their exploitation, yet these are necessary data [8].

In order to determine the level of biologically sustainable exploitation of PGR, although considerable indigenous knowledge often exists for some products, a thorough study, documented in tropical countries, has received too little attention to date. Henceforth, the need of studying PGRs used as packaging on the Mongata-Kinshasa-Kisantu axis in DRC. The objectives of this study were (i) to inventory PGRs traditionally used as packaging and their local supply ecosystems on the above-mentioned axis; (ii) to identify marketed products that are packaged with PGRs; and (iii) to identify the environmental impacts of the packaged products and the living environments of the population;

In addition to its scientific relevance in understanding the level of use of NTFPs utilized

as packaging for certain products marketed in Kinshasa, this study is a tool to assist policy makers to decide on the rate of exploitation of these NTFPs resources and in the design of initiatives for their domestication.

2. MATERIALS AND METHODS

2.1 Study Area

The following figure describes the study area and sums its administrative, geographic and hydrological location up.

This study was carried out on the Kinshasa - Kisantu axis (Madimba Territory), in the province of Kongo Central, crossing the territory of Kasangulu, and on the Kinshasa - Mongata axis, in the urban-rural municipality of Maluku in Kinshasa city. It covers 76.8% of its total surface area, i.e. 7,948.5 km^2 [9]. Several tribes occupy the site, namely: Teke, Mbala, Luba, Mongo, Wongo, Tetela, Ntandu, Mbeku, Mbuza, and Yombe.

2.2 Abiotic Aspects

The description and characterization of the study site, namely the Kisantu-Kinshasa-Mongata road axis, in terms of pedology, climate, hydrography, fauna and flora, have been documented from previous studies, notably those of Lelo [9]; Tungi [10], Latham and Konda [11], Fresco [12] and Pauwels [13].

2.3 Technical and Documentary Materials

To have different pictures, we used a Fine px S4800 camera, questionnaires, vehicles and motorbikes to get to the field; old newspapers and wooden presses, cardboard paper, transparent sticky paper; a solar dryer located at the NGO JEEP (Jardins et Elevage des parcelles) Antenna of the University of Kinshasa/DRC which help to dry samples of unidentified collected plants. The purposive sampling was used for data collection. The questionnaire was administered to 64 participants, users of PGRs in different axes. The target population were the residents found at different sites during the survey and the study period was between April 2017 and March 2018.

2.4 Biological Material

2.4.1 Vegetation

Previous studies have described the vegetation and flora of the study area. The concerned site is

Fig. 1. Administrative map of different axes considered in this study

covered with herbaceous and shrubby formations, as well as gallery forests found along large rivers (Nsele, Bombo-lumene, Maï-ndombe). The shrubby savannahs in and around the city of Kinshasa were characterized by a herbaceous stratum, often with *Loudetia demeusei*, sometimes at *Trachypogon thollonii* and *Andropogon schirensis*, and a shrubby stratum with *Hymenocardia acida, Annona senegalensis, Crossopteryx febrifuga* and *Sarcocephalus latifolius* [2,14].

2.4.2 Sampling of PGRs

It is question of these plant resources used as packaging and containers in the ecosystems located along the study axis.

2.5 Methods

Several methods were used, notably the observation, photography, and interviews. PGRs were identified at the INERA - UNIKIN Herbarium of the Department of Biology: either by analysis of botanical materials or by comparison with the herbarium's exsicata. The collected data were analyzed following descriptive statistics (mean and frequency) and discussed based on the existing literature.

3. RESULTS

3.1 Socio-demographic Characteristics

Among the characteristics of the respondents, it is worth mentioning gender, tribe and age, among others.

3.1.1 Gender

Traditionally, production activities have been gender-sensitive (Fig. 2).

From the figure, it was revealed that the exploitation of PGRs is more exercised by men than women on the Kinshasa-Kisantu axis, 56% and 44% respectively. While it is more reserved for women than men on the Kinshasa-Mongata axis, 66% and 34% respectively.

3.1.2 Tribes

Traditionally, the naming and general use of PGRs varied between tribes and even between villages, as shown in Fig. 3a, b.

On the Kinshasa - Mongata axis, six tribes using PGRs were identified, of which: Teke, Mbala, Luba, Mongo, Wongo and Tetela; while on the Kinshasa - Kisantu axis, five tribes, namely: Ntandu, Mbeku, Mbuza, Yombe and Tetela. On the Kinshasa-Mongata axis, there is a predominance of Teke (63%), while on the Kinshasa-Kisantu axis, there is a predominance of Ntandu (78%). Each of these tribes originates from these respective environments.

3.1.3 Ages

By custom, production activities are age-sensitive (Fig. 4).

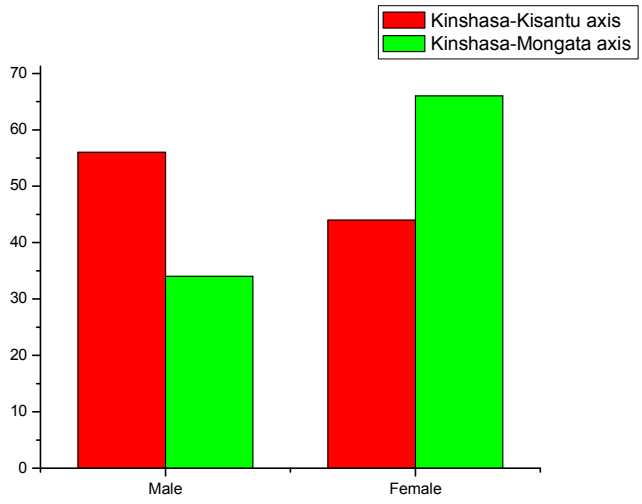
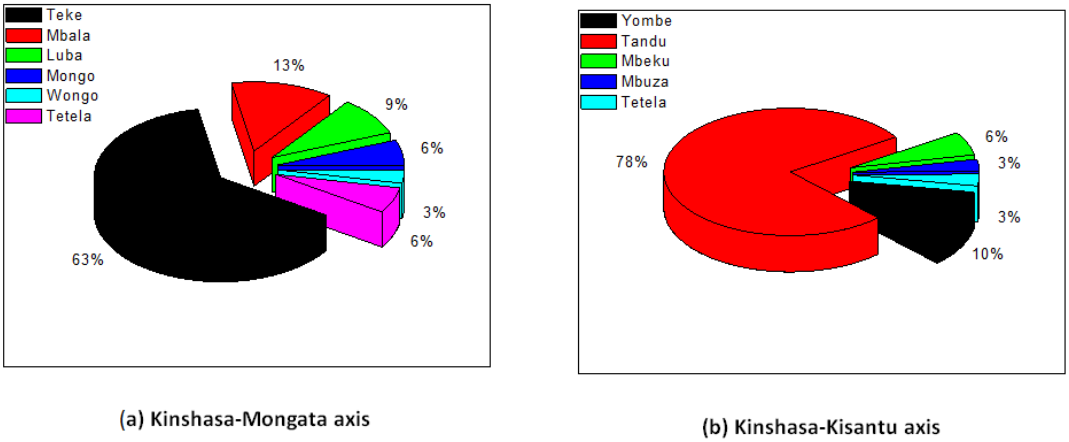


Fig. 2. Distribution of respondents by gender and study setting



(a) Kinshasa-Mongata axis

(b) Kinshasa-Kisantu axis

Fig. 3. General use of PGRs among tribes in both studied axes

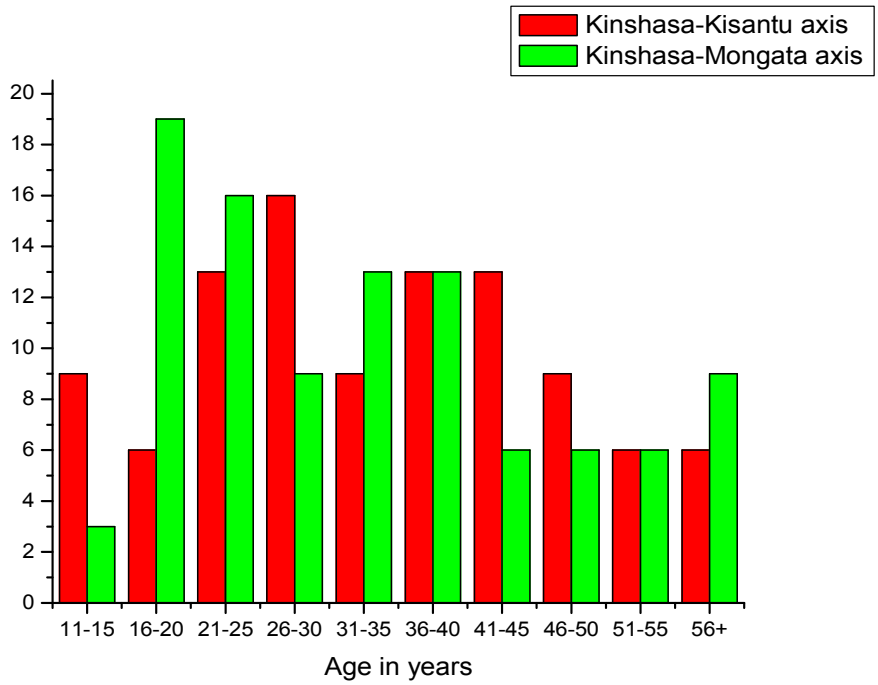


Fig. 4. Age distribution of respondents

These findings show that on both routes, the stakeholders of PGRs as packaging are both young and adults. The youngest is 11 years old while the oldest was over 56 years old. On the Kinshasa - Kisantu axis, there are more stakeholders between 16 and 20 years old (19%) than stakeholders over 45 years old (6%). While on the Kinshasa - Mongata axis, the age group between 16 and 20 years old (19%) predominates, followed by 21 to 25 years old (16%).

3.2 Identified PGRs

The PGRs identified are presented according to their families, species and vernacular names in Table 1.

Table 1. Identified PGRs are presented according to their families, species and vernacular names

N°	Famillies	Scientific names of PGRs	Vernacular names	Uses	Unit	Freq.	%
1	Araceae	*Lasimorpha senegalensis* Schott.	Kilodi ou Malodi (tandu)	Packaging leaves	Bundle	7	3.93
2	Arecaceae	*Elaeis guineensis* Jacq.	Nsinga ou singa (tandu)	Packaging rope	Bundle	14	7.87
3		*Eremospatha haullevilleana* De Wild.	Muka, lulamba, mbamba	Liana and Packaging leaves	Bundle	12	6.74
4		*Eremospatha cabrae* (De Wild.) Maun & Webl.	Mbamba ou lubamba	Liana and Packaging leaves	Bundle	13	7.30
5	Apocynaceae	*Ectadiopsis oblongifolia* (Meisn) Schltr.	Ndulusi	Packaging rope	Bundle	13	7.30
6	Cyperaceae	*Cyperus papyrus* L.	Bu ou mabu (tandu)	Packaging rope, Basket-making (basket)	Bundle	6	3.37
7	Phyllanthaceae	Hymenocardia acida Tull.	Mpeti ou kigeti (tandu)	Packaging branch	Bundle	12	6.74
8	Musaceae	Musa spp	Dikondo	Packaging leaves	Bundle	6	3.37
9	Poaceae	*Saccharum officinarum* L.	Mukuku, munsie	Packaging leaves	Bundle	8	4.49
10	Malvaceae/Tiliod	*Triumfetta cordifolia* A. Rich.	Mpunga mpunga (tandu)	Packaging rope	Bundle	15	8.43
11	eae	*Urena lobata* L.	Dinkambwala (tandu)	Packaging rope	Bundle	14	7.87
12	*Marantaceae*	*Marantochloa congensis* (K. Scheum.) J. Léonard & Mullenders	Nteti ou mateti (en tandu)	Food and Packaging leaves	Bundle	18	10.11
13		*Megaphrynium macrostachyum* (Benth) M. Redh.	Makungu (en tandu) mikungu (en teke)	Packaging leaves	Bundle	11	6.18
14		*Haumania liebrechtsiana* (De Wild. & Th. Dur.) J. Léonard		Packaging leaves	Bundle	13	7.30
15		*Sarcophrynium schweinfurthianum var . puberifolium* (O. Ktze) M. Redl. Koechlin	Biwolo (en Teke); kombe (en tetela); nkengi (en mbala); N'kombe (en mongo);	Packaging leaves	Bundle	16	8.99
16		*Thalia geniculata* L.	Bitela, ou ndumbi, ou encore nzonvi (en teki) ; tosa (en mbala) ;mubeji (en Tshiluba).	Packaging leaves	Bundle	178	100.0

Table 2. PGRs origin ecosystems

Scientific names of PGRs	Ecosystems										Total	
	Dry forests		Hydromorphic forests		Savannah		Swamps		Fields			
	Efc	%	Efc	%	Efc	%	Efc	%	Efc	%	Efc	%
Lasimorpha senegalensis	1	0.19	11	2.14	2	0.39	13	2.52	0	0.00	**27**	**5.24**
Elaeis guineensis	10	1.94	5	0.97	7	1.36	11	2.14	17	3.30	**50**	**9.71**
Eremospatha haullevilleana	16	3.11	9	1.75	1	0.19	7	1.36	2	0.39	**35**	**6.80**
Eremospatha cabrae	19	3.69	8	1.55	2	0.39	4	0.78	1	0.19	**34**	**6.60**
Ectadiopsis oblongifolia	11	2.14	2	0.39	6	1.17	1	0.19	3	0.58	**23**	**4.47**
Cyperus papyrus	3	0.58	4	0.78	1	0.19	21	4.08	3	0.58	**32**	**6.21**
Hymenocardia acida	23	4.47	7	1.36	3	0.58	2	0.39	9	1.75	**44**	**8.54**
Musa spp	6	1.17	1	0.19	4	0.78	2	0.39	22	4.27	**35**	**6.80**
Saccharum officinarum	3	0.58	1	0.19	3	0.58	1	0.19	23	4.47	**31**	**6.02**
Triumfetta cordifolia	15	2.91	2	0.38	2	0.19	2	0.38	2	0.38	**22**	**4.27**
Urena lobata	6	1.6	1	0.19	0	0.00	2	0.38	1	0.19	**10**	**1.94**
Marantochloa congensis	25	4.85	0	0.00	0	0.00	1	0.19	11	2.14	**37**	**7.18**
Megaphrynium macrostachyum	23	4.47	1	0.19	2	0.39	0	0.00	10	1.94	**36**	**6.99**
Haumania liebrechtsiana	1	0.19	21	4.08	2	0.39	2	0.39	2	0.39	**28**	**5.44**
Sarcophrynium schweinfurthianum var. puberifolium	25	4.85	11	2.14	1	0.19	4	0.78	7	1.36	**48**	**9.32**
Thalia geniculata	15	2.91	4	0.78	2	0.39	1	0.19	1	0.19	**23**	**4.47**
Total	**202**	**39.22**	**88.0**	**17.09**	**37.0**	**7.18**	**74.0**	**14.37**	**114.0**	**22.14**	**515.0**	**100.00**

Legend: Efc: effective; %: percentage

3.3 Diversity of PGRs

A total of 16 plant species used as packaging belonging to 9 families have been identified, the most preponderant of which are the Marantaceae (5 species) and the Arecaceae (3 species). There are more Arecaceae (3 species) on the Kinshasa - Kisantu Axis than on the Kinshasa - Mongata Axis where there are more Marantaceae (4 species) followed by Arecaceae (2 species). All other floristic groups are monospecific.

As regards to specific diversity, on the two road axes, 11 common species are identified, namely: *Elaeis guineensis, Lasimorpha senegalensis, Eremospatha haullevilleana* and *E. cabrae*; *Ectadiopsis oblongifolia, Cyperus papyrus, Hymenocardia acida, Musa spp, Saccharum officinarum, Triumfetta cordifolia, Urena lobata* and *Marantochloa congensis.* However, four differential species are listed as follows: *Megaphrynium macrostachyum, Haumania hiebrechtsiana, Sarcophrynium schweinfurthianum var. puberifolium* Koechlin and *Thalia geniculata* L. were identified on the Kinshasa-Mongata axis.

Regarding the use, each PGR can play a distinct role in the packaging of one or more products. These PGRs are used primarily as packaging and rope to bind certain products during manufacture, construction, the making of certain works of art and transport, and only one is used both as a vegetable and for packaging, of which *Megaphrynium macrostachyum*. Numerous PGRs are sold in bundles as a unit; their selling price varies between $0.14 and $0.28 depending on whether they are leaves or liana, respectively.

3.4 Ecosystems of Origin of PGRs

Fig. 5 identifies the ecosystems from which PGRs are sourced by respondents.

Fig. 5 shows that 39% of people using PGRs for packaging obtain their supplies from dry forests; 22% from agricultural fields; 17% from hydromorphic forests; 14% from swamps and 8% from savannahs.

Table 2 presents different species used as PGRs from their ecosystem of origin.

It can be observed from the table that in the dry forests: *Marantochloa congensis* and *Sarcophrynium schweinfurthianum var. puberifolium* (4.85%) are the most abundant species in terms of specimens used while *Saccharum officinarum, Cyperus papyrus, Lasimorpha senegalensis* and *Haumania liebrechtsiana* are the least abundant species (0.58% and 0.19% respectively). In the

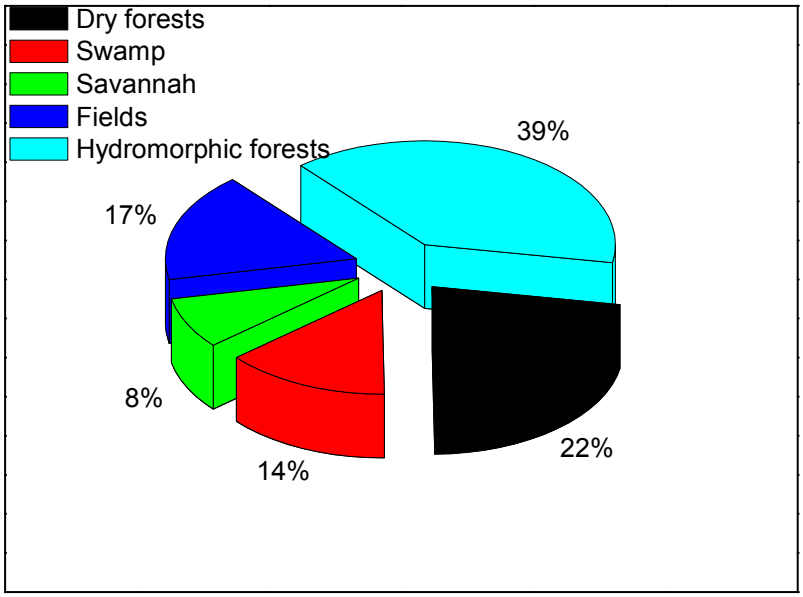


Fig. 5. PGRs origin ecosystems

hydromorphic forests, *Haumania liebrechtsiana* constitutes the most abundant species (4.08%) followed by *Lasimorpha senegalensis* and *Sarcophrynium schweinfurthianum var. puberifififolium* (2.14%), whereas *Megaphrynium macrostachyum, Saccharum officinarum, Musa spp* are monospecific (0.19%). It was observed a total absence of *Marantochloa congensis* in this ecosystem. *Elaeis guineensis* and *Ectadiopsis oblongifolia* are found abundantly in the savannah with 1.36% and 1.17% respectively while *Urena lobata* and *Marantochloa congensis* are not found in the aforementioned ecosystem. *Sarcophrynium schweinfurthianum var. puberifififolium* is the least abundant species. In the swamps, *Cyperus papyrus* is the most abundant (4.08%) while *Megaphrynium macrostachyum* is absent. At last, in the fields, it is observed that *Saccharum officinarum* and *Musa spp.* are the most abundant species meanwhile *Lasimorpha senegalensis* is absent and *Eremospatha cabrae, Urena lobata* and *Thalia geniculate* are less represented.

3.5 Availability of PGRs

3.5.1 Market availability of PGRs

Table 3 provides information on the availability of PGRs both in markets and in their natural environments.

Fig. 6 shows the periods of availability of PGRs in urban markets according to seasons.

As observed, 50% of PGRs users indicate that these resources are available all year round; 34% of users state that these resources are available in the rainy season and 16% in the dry season.

3.5.2 Sustainability of PGRs in their natural environment

The future exploitation of PGRs depends on two options for a sustainable management of exploited PGRs i.e. domestication or regulated seasonal harvesting. Table 4, provides different opinions of people on the possibility of making PGRs sustainable.

From this table, it appears that 51.89% of respondents recognize that these PGRs may disappear one day; 48.11% do not think that these resources will disappear, but they believe in the natural dynamics of their settlement.

3.6 Possibilities for the Domestication of PGRs

In a general way, it is possible to domesticate several common PGRs, either by the *in situ* or *ex situ* approach (Fig. 7).

Table 3. Availability of PGRs in

Scientific names of PGRs	Availability period						Total	
	All the year long		Dry season		Rainy season			
	Efc	%	Efc	%	Efc	%	Efc	%
Lasimorpha senegalensis	23	3.81	11	1.82	22	3.64	56	9.27
Elaeis guineensis	15	2.48	5	0.83	9	1.49	29	4.80
Eremospatha haullevilleana	11	1.82	9	1.49	10	1.66	30	4.97
Eremospatha cabrae	19	3.15	8	1.32	13	2.15	40	6.62
Ectadiopsis oblongifolia	11	1.82	2	0.33	6	0.99	19	3.15
Cyperus papyrus	27	4.47	4	0.66	12	1.99	43	7.12
Hymenocardia acida	23	3.81	7	1.16	11	1.82	41	6.79
Musa spp	24	3.97	5	0.83	15	2.48	44	7.28
Saccharum officinarum	19	3.15	3	0.50	7	1.16	29	4.80
Triumfetta cordifolia	15	3.78	3	0.50	12	1.99	36	5.96
Urena lobata	9	1.78	0	0	0	0	0	0
Marantochloa congensis	25	4.14	12	1.99	21	3.48	58	9.60
Megaphrynium macrostachyum	23	3.81	7	1.16	22	3.64	52	8.61
Haumania liebrechtsiana	18	2.98	6	0.99	14	2.32	38	6.29
Sarcophrynium schweinfurthianum var. puberifififolium	25	4.14	6	0.99	12	1.99	43	7.12
Thalia geniculata	21	3.48	8	1.32	17	2.81	46	7.62
Total	305	50.50	96	15.89	203	33,61	604	100,00

Legend: Efc: effective; %: percentage

Table 4. Sustainability of PGRs

Scientific names of PGRs	Notice of disappearance of PGRs				Total	
	Yes		No			
	Frequency	%	Frequency	%	Frequency	%
Lasimorpha senegalensis	13	4.98	34	6.76	47	9.34
Elaeis guineensis	15	5.74	31	6.16	46	9.15
Eremospatha haullevilleana	24	9.13	4	0.80	28	5.57
Eremospatha cabrae	6	1.19	24	4.77	30	5.96
Ectadiopsis oblongifolia	4	0.80	29	5.77	33	6.56
Cyperus papyrus	17	3.38	8	1.59	25	4.97
Hymenocardia acida	12	2.39	26	5.17	38	7.55
Musa spp	10	1.99	13	2.58	23	4.57
Saccharum officinarum	11	2.19	13	2.58	24	4.77
Triumfetta cordifolia	16	3.18	9	1.79	34	6.76
Urena lobata	9	3.44	3	1.23	12	2.38
Marantochloa congensis	27	5.37	12	2.39	39	7.75
Megaphrynium macrostachyum	25	4.97	7	1.39	32	6.36
Haumania liebrechtsiana	24	4.77	11	2.19	35	6.96
Sarcophrynium schweinfurthianum var . puberifolium	25	4.97	11	2.19	36	7.16
Thalia geniculata	23	4.57	10	1.99	33	6.56
Total	**261**	**51.89**	**242**	**48.11**	**503**	**100.00**

Table 5. Packaged products with PGRs

N°	Packaged products			Interaction between PGRs with packaged products			%
	Products	Freq.	%	GPRs	interaction	freq	
1	Chikwangue	25	37.31	*Musa spp*	Color	2	11.11
	Chikwangue			*Lasimorpha s.*	Color	4	22.22
	Chikwangue			*Marantochloa*	Color	2	11.11
2	Pineapple	3	4.47	-	-		
3	Firewood	1	1.49	-	-		
4	Courge (liboke)	2	2.98	*Sarcophrynium*	Taste	1	5.55
5	Sugar cane	2	2.98	-	-		
6	Mushrooms	2	2.98	-	-		
7	Fresh fish	11	16.41	-	-		
	Fish cooked with leaves			*Marantochloa*	Taste	6	33.33
8	Fern	3	4.47	-	-		
9	« Mikungu »	1	1.49	-	-		
10	Rope	6	8.95	-	-		
11	Maranthaceae leaves	6	8.95	-	-		
12	Papyrus	1	1.49	-	-		
13	Charcoal	3	4.47	-	-		
14	Cassava leaves	1	1.49	-	-		
15	*Thalia geniculata*			*Thalia*	mold	1	5.55
16	Pork meat cooked in leaves (liboke)			*Sarcophrynium*	none	2	11.11
	Total	**67**	**100**			**18**	**100**

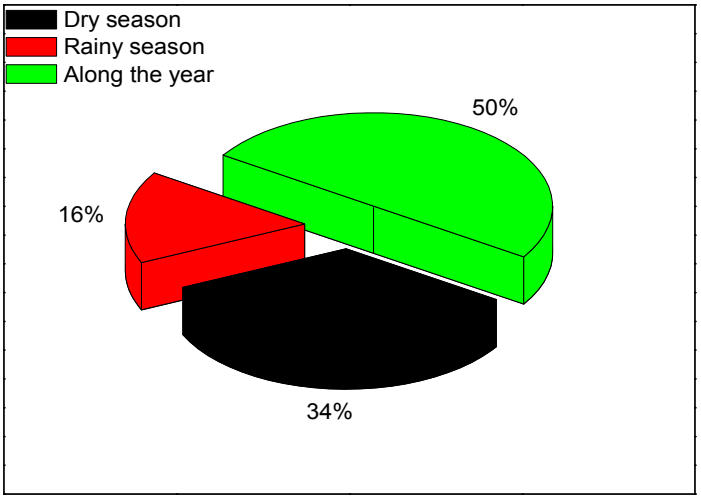


Fig. 6. Market availability periods for PGRs

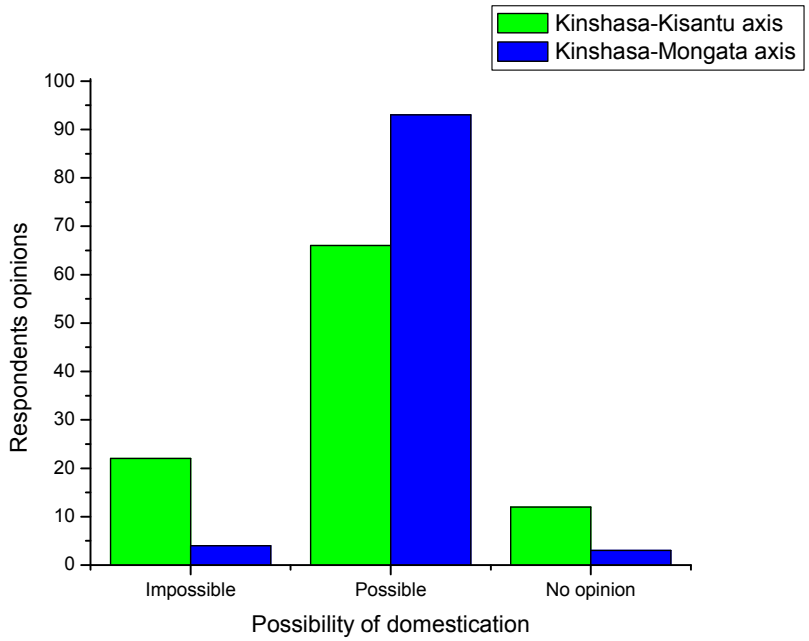


Fig. 7. Potential domestication of different PGRs

On the Kinshasa-Kisantu axis, 65.62% state that it is possible to domesticate several species used as PGRs they exploit while 21.87% do not believe in any possibility of domestication and 12.51% have no opinion. On the other hand, 93.33% affirm that the domestication of these exploited species is possible while 3.33% are skeptic and without any opinion on this issue.

3.7 Regulating the Seasonal Collection of PGRs

To circumvent the hypothesis of the disappearance of these species, in addition to their domestication in the field, which seems possible according to 93% of respondents on the Kinshasa-Mongata axis and 22.14% on the

Kinshasa-Kisantu axis who already do so for the improvement of the marketing chain. Biloso [2] observed on the Mongata-Kinshasa axis, where one group of stakeholders works on even days and another on odd days, is a start of appreciable local organization that needs to be strengthened.

3.8 Packaged Products and Interactions between Products

Fig. 8 presents the products packaged with PGRs by different tribes and some of the interactions that can be observed.

3.8.1 Products packaged with PGRs and interactions between packaged products

Different packaged products found in different sites are presented in the figure (Fig. 8).

On the Mongata-Kinshasa-Kisantu axis, 14 separate products were counted, notably 9 food and 5 non-food products. These are respectively Cassava bread (Chikwangue), pineapple, Gourd, sugar cane, mushrooms, fresh fish (or cooked inside specific leaves called “liboke”), fern, "mikungu", cassava leaves, and on the other hand, rope, charcoal, papyrus, marantaceae leaves and *Megaphrynium macrostachyum*. Among these products, Chikwangue proved to be the most commercially packaged product with PGRs (37.31%); followed by fish (16.41%) and balls of string and marantaceae leaves (8.95%).

3.8.2 Interactions between packaged products and PGRs

The interaction between packaged products and the PGRs is presented in Table 5.

As for the interaction with packaged products, the findings above indicate that some products packaged with PGRs are undergoing some modifications/alterations: 9.52% of stakeholders of banana and Marantachloa leaf. While 19.04% of stakeholders of *Lasimorpha senegalensis* agree that : 1) these leaves confer a brownish coloration to chikwangue (cassava bread); 2) *Sarcophrynium* confers a flavour of squash in foil parcel (gourds in liboke); and 100% of stakeholders recognize that *Thalia geniculata* leaves accelerate the development of mould on packaged products.

3.9 Environmental Impacts

Environmental impacts can be divided into biophysical and socio-economic components.

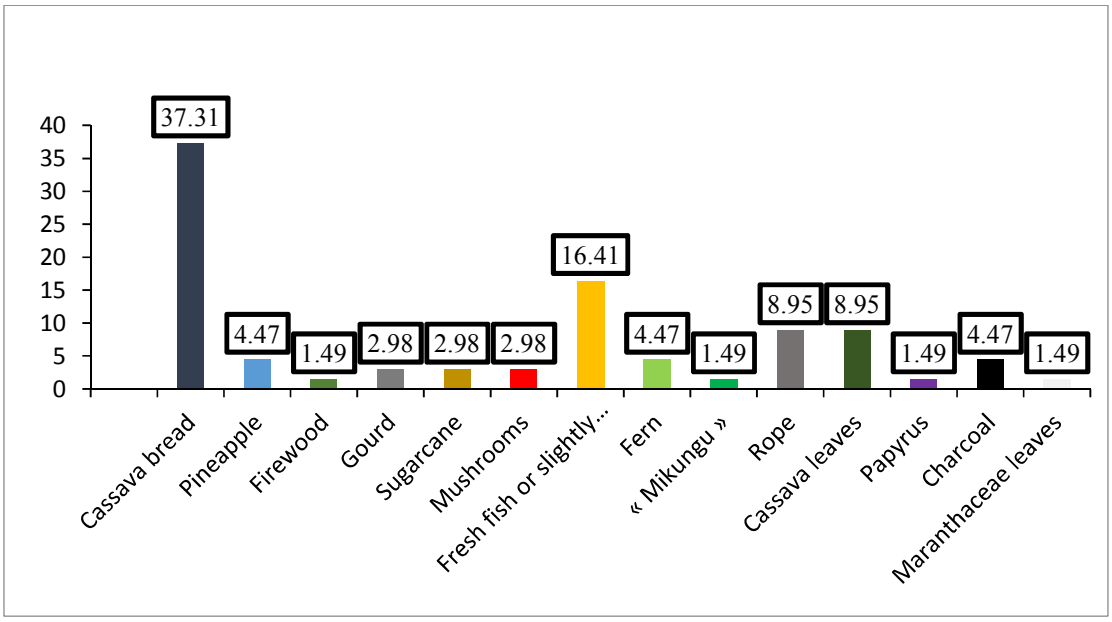


Fig. 8. Products packaged with PGRs

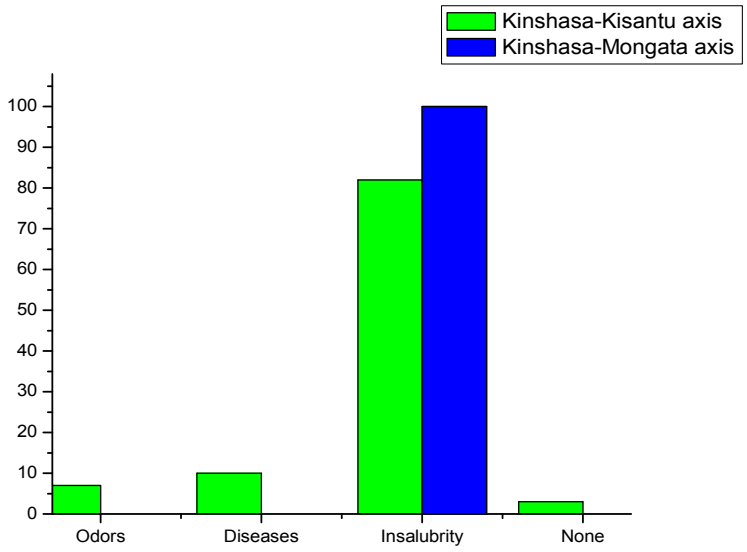


Fig. 9. Environmental impacts associated with the operation of these different PGRs

3.9.1 Biophysical impacts

Fig. 9 show the adverse effects resulting from the use of PGRs as packaging in the physical and biological environment.

It was observed from above that 100% of respondents on the Kinshasa-Mongata axis recognize that the plant packaging used becomes a source of insalubrity in living environments against 82% on the Kinshasa-Kisantu axis where 10% mentioned the case of diseases and 7% the case of bad smell respectively.

3.9.2 Socio-economic impacts

Fig. 10 shows that the sectors of life that benefit most from income from the sale of PGRs are: children's schooling, medical care and household food.

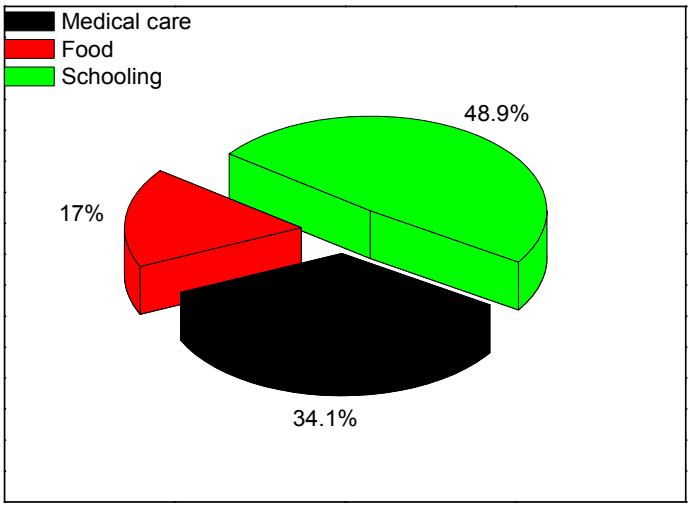


Fig. 10. Allocation of income to household expenses

Table 6. Allocation of income to household expenses

Scientific names of PGRs	Income allocation						Total	
	Schooling		Medical care		Food			
	Efc.	%	Efc.	%	Efc.	%	Efc.	%
Lasimorpha senegalensis	21	3.61	14	2.41	23	3.96	58	9.98
Elaeis guineensis	14	2.41	5	0.86	10	1.72	29	4.99
Eremospatha haullevilleana	11	1.89	9	1.55	10	1.72	30	5.16
Eremospatha cabrae	17	2.93	8	1.38	13	2.24	38	6.54
Ectadiopsis oblongifolia	9	1.55	2	0.34	5	0.86	16	2.75
Cyperus papyrus	25	4.30	4	0.69	12	2.07	41	7.06
Hymenocardia acida	22	3.79	7	1.20	11	1.89	40	6.88
Musa Spp	20	3.44	5	0.86	15	2.58	40	6.88
Saccharum officinarum	19	3.27	3	0.52	9	1.55	31	5.34
Triumfetta cordifolia	17	2.98	2	0.34	8	1.37	27	4.64
Urena lobata	4	0.68	1	0.17	4	0.68	9	1.54
Marantochloa congensis	21	3.61	12	2.07	21	3.61	54	9.29
Megaphrynium macrostachyum	23	3.96	7	1.20	19	3.27	49	8.43
Haumania liebrechtsiana	18	3.10	6	1.03	14	2.41	38	6.54
Sarcophrynium schweinfurthianum var . puberifolium	24	4.13	6	1.03	12	2.07	42	7.23
Thalia geniculata	19	3.27	8	1.38	12	2.07	39	6.71
Total	284	48.88	99	17.04	198	34.08	581	100.00

In terms of socio-economic impacts, the sale of these resources constitutes a source of income that is no less important in several households: 48.9% of the respondents pay for their children's school fees; 34.1% supplement their food needs and 17.% supplement their health needs.

Table 6 presents the names of species which serve as PGRs for different expenses undertaken.

4. DISCUSSION

It is known that Africa's strength lies in its natural resources, including the genetic resources that are the foundation for growth and stability in agriculture, forestry and environment. Africa's economies, cultures and political systems are primarily dependent, albeit precariously, on how PGRs are conserved and utilized. In the light of this, the continent's economic transformation and its ability to integrate itself into the evolving global system, to a large measure, depends on agricultural transformation that is based on PGRs [15].

4.1 Socio-demographic Characteristics

Africa's wealth of biological resources in general and plant genetic resources in particular, is a critical element in alleviating poverty, ensuring food security, and developing new medicines in addition to their immeasurable social and cultural value and significance.

Out-of-school children, the majority of whom are girls, engage in the exploitation of PGRs used as packaging from a younger age (11 years) to the very old age of over 56 years. This is a way of mobilizing the whole household to participate in solving household problems, mainly children's schooling, food as well as health problems. These observations are similar to what was reported by Kakumbi [16]. Meanwhile, Dounia [17] reported that PGRs are an equally important source of income in many households and help so much for the survival.

The dominance of these two indigenous tribes, namely Ntandu on the Kinshasa-Kisantu axis; and Téké on the Mongata-Kinshasa axis, influences the culture that we would like to have the inter-ethnicity or resulting from the contribution or juxtaposition of local traditions. It is necessary in our African cities to avoid frustration, rejection of the other because they do not integrate our beliefs [9].

4.2 PGRs

The Kinshasa-Kisantu axis has more PGRs used as packaging than the Mongata-Kinshasa axis; this would be the result, as we have noticed in the field, of the domestication of PGRs in the

fields and around dwellings; but also, of the influence of the Kisantu Botanical Garden, the Mayombe forest and the Luki Biosphere Reserve.

Meanwhile, on the Mongata-Kinshasa axis, the small number of PGRs used as packaging would be justified by the destruction of ecosystems following the type of land development. These observations are similar to Dounia [17]. Moreover, due to the extensive occupation of land for agricultural purposes (agro-industrial farm of Bukanga Lonzo, agricultural villages, agricultural mechanization) and, to the carbon sinks of the agroforests of IBIS and CADIM (Centre d'appui au Développement Integral de Mbakana – Mbankana Integral Development Support Centre), it was observed that forests are disappearing. The due observation was confirmed by Lelo [9]. This author pointed out that around Kinshasa, several hectares of forest are disappearing per year due to the urban deforestation.

Furthermore, these findings are consistent with those of Biloso [2], who reported that 10 families with 19 species of NTFPs are used as packaging, including nine species common with those of this study. The majority of farmers noted that these PGRs are declining and may disappear, as also pointed out by Yvonnick et al. [18] in Senegal. Also following the non-domestication or unregulated harvesting in DRC as noted by Guillou [19].

4.3 Packaged Products

4.3.1 Diversity of packaged products

As for packaged products, in addition to being packaged in various quantities in proportion to the customers' purses according to Susanna's marketing strategy [20], some are packaged for cooking, preservation and marketing, notably chikwangue and squash, while others are packaged for transport to the point of sale or consumption, notably pineapple, firewood, charcoal, as well as PGRs themselves packaged in bundles, as confirmed by Yvonnick [18] and Gontard [21].

4.3.2 Interaction between packaged products and PGRs

Several food products are perishable by nature and require protection from spoilage during their preparation, storage, and distribution to give them desired shelf life. Therefore, the demand for minimally processed, easily prepared, and ready-to-eat fresh food products, globalization of food trade, and distribution from centralized processing pose major challenges for food safety and quality. Food products can be subjected to contamination by bacteria and fungi. Many of these microorganisms can cause undesirable reactions that deteriorate flavor, odor, color, sensory, and textural properties of foods [22].

In terms of interactions, the leaves of *Musa spp*, *Lasimorpha senegalensis*. and *Marantochloa* give a brownish coloration to the cassava bread called "chikwangue' while those of *Sarcohrynium* give a good aroma to the squash in foil parcel (gourd in liboke). These findings are consistent with Gontard [21] whom reported that natural materials contain active compounds - aromatics, dyes, enzymes (e.g. papain), antimicrobial (essential oils) and microbial agents, which migrate during the preservation of the plant leaf to the packaged food product by favorably modifying its color, odor, texture and by limiting or promoting the development of undesirable microorganisms such as moulds for *Thalia geniculata* PGRs.

4.3.3 Environmental impacts of PGRs

All these PGRs, after their use in households, are a cause of public unhealthiness due to the lack of a waste collection organization [23,24]. According to Lelo [9], household waste generally represents 62.2% of organic matter who estimated it at 66%. These pollute the consumption environment, especially the PGRs used as packaging for Chikwangue (cassava bread), as Kakumbi [16] pointed out. They cause visual pollution by the quantity of leaves spilled into the consumer environment per week (i.e. 1 975 050 leaves per week and per vehicle) and olfactory pollution following the putrefaction of the leaves, which gives off nauseating odors.

5. CONCLUSION

The forest and savannah ecosystems of the Mongata - Kinshasa - Kisantu axis are reservoirs of PGRs, of which the exploitation contributes to the socio-economic well-being of thousands of rural households without income. Among these PGRs include those traditionally used as packaging, precisely 16 species grouped in 9 families dominated by Marantaceae. Thanks to the income generated by the sale of PGRs used as packaging, the activity has become for the indigenous people, for more than 90%, an

additional family activity to agriculture; and a commercial product for other tribes.

Children, generally out of school, precisely girls, are involved from an early age. It is a way for parents to mobilize the whole household to participate in solving household problems. However, all these PGRs, after their use in households, due to lack of good waste collection organization, turn into unsanitary conditions. The latter pollutes the consumption environment. They cause visual pollution by the quantity of leaves dumped in consumption environments per week and olfactory pollution following the putrefaction of the leaves, which gives off nauseous odors.

At this rate of extraction for marketing and without a policy of supervision or support for predatory organizations, these plant resources are in danger of disappearing in the short term. The urgent need is to identify all these PGRs and to study their technical cultivation routes with a view to their domestication.

The *ex situ* domestication initiatives observed on the Kinshasa-Kisantu axis where research has been carried out, in particular cultivation in the field or conservation of species in the field during cultivation set-ups, should be the starting point for experimental crop trials. As for packaged products, in addition to being packaged in various quantities in proportion to the customers' purses according to marketing strategies, some are packaged for cooking, preservation and marketing and others for transport to the point of sale or consumption and PGRs themselves packaged in bundles. These findings are an alert for managers of PGRs and the environment to take appropriate measures for the sustainable use of these resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Yabuda HK, Mabe JBK, Koyagialo GJL, Ndembo NJL, Masengo CA, Djolu RG, Bongo GN, Ngbolua KNN. Impact of artisanal wood harvesting on the availability of non-timber forest products in a community-based forest in Gbado-Lite, DRC. International Journal of Plant Science and Ecology. 2019;5(3):37-42.
2. Biloso MA. Development of non-wood forest products from the *Bateke plateaux* on the outskirts of Kinshasa (DR Congo). Thesis presented to obtain the title of Doctor of Agronomic Sciences and Biological Engineering. Faculty of Sciences ULB. 2008;167.
3. Arbonnier M. Trees, shrubs and lianas of the dry arid zones of West Africa. 2nd edition, CIRAD –MNHN. 2002;573.
4. Ahenkan A and Boon E. Improving Nutrition and Health through Non-timber forest products in Ghana. Journal of Health and Population Nutrition. 2011;29 (2):141-148.
   DOI: 10.3329/jhpn.v29i2.7856
5. Wong JLJ, Kiirsti T, Baker N. Non-timber forest products. Assessment of resources in non-wood forest products: experience and principles of biometrics. FAO, Rome. 2001;118.
6. Choo KY, Jalonen R, Hong LT and Sim HC. Forest genetic resources, conservation and management: National consultative workshops of seven South and Southeast Asian countries. APFORGEN. 2009;156.
7. Ngbolua KN, Ngemale M, Masengo AC, Ndolete GJP, Bongo NG, Ndanga BA, Tshibangu STD, Tshilanda DD. Survey on the sale of *Megaphrynium Macrostachyum* (Marantaaceae) leaves in Gbado-lite city and surroundings (Nord Ubangi, Democratic Republic of the Congo). Budapest International Research in Exact Sciences. 2(2):157-167.
8. FAO. Preface in, Non-wood forest products. Assessment of resources in non-wood forest products: experience and principles of Biometrics. FAO, Rome. 2001;iii-iv.
9. Lelo N. Kinshasa: City and environment. Edition Le Harmattan. 2008;259.
10. Tungi T. Agroforestry systems used around Kinshasa. Practical work of students in Water and Forests. Faculties of Agronomic Sciences, University of Kinshasa. 2012;32.
11. Latham P, Konda KM. Useful plants from Bas-Congo, Democratic Republic of Congo. Mystole publications, 2nd edition. 2007;344.
12. Fresco L. Improved agricultural techniques for Kwango-Kwilu. FAO, Mediaspaul. 2009; 145.
13. Pauwels L, Nzayilu N. Guide to trees and shrubs in the Kinshasa - Brazzaville

region. Meise. Botanical Garden of Belgium. 1993;495.
14. Habari MJP. Floristic, phytogeographic and phytosociological study of the vegetation of the Kinshasa region and of the middle basins of the N'djili and N'sele rivers in the Democratic Republic of Congo. Unpublished PhD dissertation, Faculty of Sciences, University of Kinshasa. 2009; 263.
15. Nnadozie KC, Kiambi D, Kameri-Mbote P, Atta-Krah K, Mugabe J. Plant Genetic Resources in Africa's renewal: Policy, Legal and Programmatic issues under the new partnership for Africa's development. International Environmental Law Research Centre. 2003;33.
16. Kakumbi KM. Effect of the actions of the J.E.E.P project on the quality of the environment in the municipality of Kisenso. Ethno-botanical aspects. Unpublished MSc dissertation, University of Kinshasa. 1999; 154.
17. Dounia L. African biodiversity: Foundation for the future. Biodiversity support program. WWF/USAID/Nature Conservancy. 1993;168.
18. Yvonnick H, Papin C and Sicard P. Suppliers of packaging and packaging materials in Bulletin of the Technology network and partnership in the food industry. packaging file, TPA. 1999;16:33-36.
19. Guillou M. Universal Dictionary, 2nd edition. Ed UNICEF.VANVES Cedex. 1988;1503.
20. Susanna T. The revolution is underway, in review Spore N ° 176. CTA. 2015;13-17.
21. Gontard N. Why pack and how in Bulletin of the Technology network and partnership in agrifood. packaging file, TPA. 1999;16:7 -11.
22. Lucera A, Costa C, Conte A and Matteo AND. Food applications of natural antimicrobial compounds. Frontiers in Microbiology. 2012;3(287):1-13.
23. Kumar S, Smith SR, Fowler G, Velis C, Kumar SJ, Arya S, Kumar R and Cheeseman C. Challenges and opportunities associated with waste management in India. Royal Society Open Science, 2017;4(3):1607-64. DOI: 10.1098/rsos.160764
24. Ferronato N, Torretta V. Waste mismanagement in Developing countries: A review of global issues. International Journal of Environmental Research and Public Health. 2019;16 (1960):1-28.

APPENDICES

1.1 Packaged Products

1

2

3

Fig. A1 to A3. Different packaging GPRs and their uses

1.2 GPRs and Wastes

4

5

Fig. A4 to A5. Marantaceae leaf litter bins

1.3 Oil palm leaves as transport basket

6

7

8

Fig. A6 to A8. Oil palm leaves covered packs of charcoal

1.4 Cassava bread Manufacturer and Child Seller of Outpatient Packaging PGRs

1.5. Modes of Transport (from left to right: Mini - bus, Car and van)

Transport vehicles loaded with RPGs to markets in the city of Kinshasa

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/57418