Article

Exploitation of Non-Timber Forest Products in the Eastern Part of DR Congo

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Abstract: Forests are a large reservoir of biodiversity on which riparian populations frequently rely. Non-timber forest products (NTFPs) are an important source of income for millions of people living in forest-adjacent communities. This study aims at characterizing the types and uses of NTFPs in order to determine whether their exploitation in the eastern Democratic Republic of the Congo is sustainable. Interviews and direct observation were carried out with NTFP stakeholders (harvesters, sellers, and consumers) in Kalonge, near the Kahuzi-Biega National Park. The results showed that 40 NTFPs of plant origin and 10 NTFPs of animal origin are commonly exploited and used in food and traditional medicine. The most common NTFP harvesting techniques are debarking, picking, digging up, felling, and wine extraction, which are all tailored to the plant part. A significant relationship (p-value< 0.001) has been established between the types of NTFPs used and harvesting methods as well as between the types of NTFPs used and organs retrieved. NTFP products are mainly obtained from the natural forest KBNP but also in the woodland, trees grown outside of forest or through domestication. Their abundance, however, is hampered by the extraction of wood for charcoal, energy, and timber, as well as agricultural expansion. The supply of NTFPs is determined by the market demand for the products, the nature of the product, and the ease of disposal. The NTFPs value chain in Kalonge is important to the local economy, however exploitation of NTFP products remains uncontrolled and should be well managed to ensure sustainability.

Keywords: NTFP; sustainable exploitation; use of NTFP

1. Introduction

Forests are a large repository of biodiversity, including non-timber forest products (NTFPs), on which riparian populations rely frequently [1–3]. One of these NTFPs' distinguishing features is their accessibility, even to people without cultivable land and/or sufficient income [4,5]. NTFPs are frequently the most visible manifestation of the value of the forest to local people, making them an important factor in the conservation of the overall forest resource. NTFPs have also gained popularity in recent years due to their contribution not only to improving local populations' livelihoods but also to the conservation of plant biodiversity [6], and their use can generate higher revenues than other productive land use options, such as timber extraction or livestock production [7].

According to some studies, NTFPs account for approximately 25% of the global income of approximately one billion people **[7]**. It is estimated that approximately 300 million people living

 doi:10.20944/preprints202212.0575.v1

near tropical forests rely on NTFPs for some or all of their income **[8]**. NTFPs continue to be an important component of household nutrition and health, as well as a source of income, in Africa, a continent with an estimated 21% forest cover **[9]**. Indeed, NTFP play an important socioeconomic role, particularly for women, because the sale of raw or processed products generates significant income for many households, particularly during the lean season **[10,11]**. The trade and consumption of these products contribute significantly to the household economy in the Democratic Republic of the Congo (DRC) **[12]**.

With an enormous forest heritage **[13]** representing 10% of the world's tropical forest reserves, nearly 50% of Africa's dense forests, and 60% of Congo Basin forests **[14]**, the DRC is a country where the forest provides important services at all scales. As a result, the DRC's NTFP sector is of interest, both for its contribution to the well-being of local farmers and urban intermediaries and for its commercial potential in the development of new medical, cosmetic, and food products **[15]**.

However, a given wild bioresource's ability to continue meeting both subsistence and market needs is heavily reliant on sustainable harvesting and appropriate management practices **[16]** . Unfortunately, many forests and protected areas are subjected to anthropogenic activities such as agriculture, livestock, poaching, carbonization, uncontrolled bush fires, and uncontrolled harvesting of NTFPs **[2,3]**, which pose a threat to the expansion of biological diversity.

Furthermore, the lack of systematic data to assess the contribution of NTFPs to household income and improved food security, as well as the absence of official management and promotion programmes for these products, are barriers to the NTFP sector's prosperity and the improvement of the population's living standards. The absence of NTFPs in government development strategies and policies exposes them to unsustainable, unregulated, and unauthorized exploitation, such as bush meat hunting **[17,18]**.

This is the case of the Kalonge municipality, which is located near the Kahuzi Biega National Park (KBNP) and where, according to **[19]**, the forest is a significant resource. The Albertine Rift Mountains in Africa, where the KBNP is located, are known for their exceptional biodiversity **[20]**, with approximately 7,500 plant and animal species recorded, more than 1,000 of which are endemic **[21]**, and are thus linked to NTFP exploitation and commercialization issues, particularly in the Kalonge municipality located around the KBNP. Given the scarcity of information on the region's NTFP potential, this study aims to (1) inventory the main NTFPs, types of use, and organs used; (2) assess the harvesting system and identify anthropogenic activities that impact NTFP sustainability; and (3) assess NTFP consumption and marketing in the eastern mountainous region of DRC, specifically in the Kalonge municipality.2. Materials and Methods

2.1. Studey area

This study was carried out in the mountainous eastern part of the DRC, in the province of South Kivu, Kalehe territory, Kalonge municipality around the Kahuzi Biega National Park (KBNP). Kalonge with its 750 Km² area is bounded to the north by the Buholo community and the Kalima municipality, to the south by the Kabare territory, to the west by the Kahumba, Biapoka rivers and the Nyamusenge massif separating it from the Shabunda zone, and to the east by the KBNP [22] (Figure 1).

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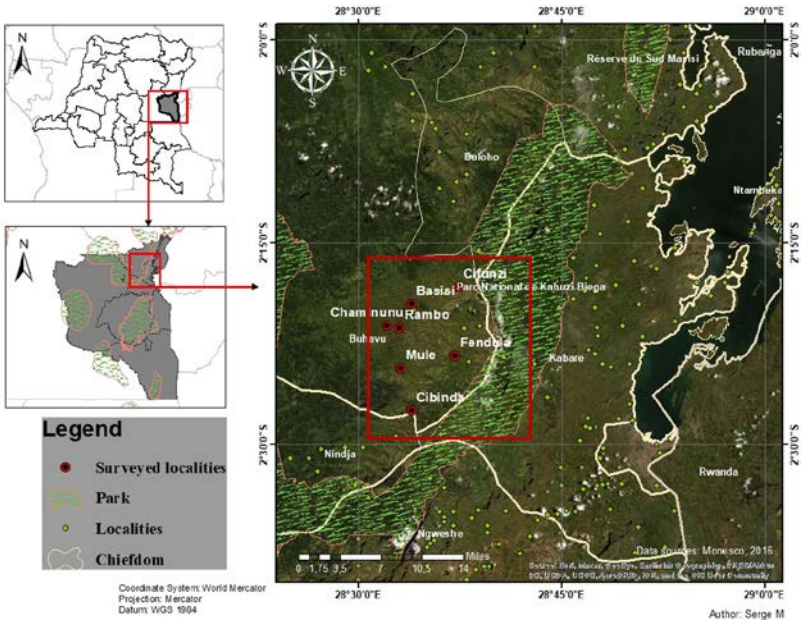

Figure 1. Surveyed localities located in the east of the DRC, in the South Kivu province, in the vicinity of KBNP, Kalonge municipality

The Kalonge municipality experiences a mountain climate, as it is located along the Mitumba Mountain range. It has two main seasons: the rainy season which lasts ~9 months from September to May and the dry season which lasts more or less 3 months from June to August. Annual rainfall varies from 1300 to 1680 mm and the average annual temperature is 17.5ºC, with absolute maximum temperatures ranging from 25.5ºC to 28°C [23].

2.2. Data collection

Several techniques were used during data collection including literature review, interviews with NTFP stakeholders and direct observation. In order to have a good understanding of the exploitation, marketing and consumption of NTFPs in the Kalonge municipality, a survey was conducted. Using the accidental sampling method, a sample of 130 individuals was selected, including 70 harvesters, 30 traders and 30 consumers (Table 1). Harvesters were surveyed in the seven localities of the Kalehe namely Rambo, Cifunzi, Fendula, Mule, Cibinda, Chaminunu and Basisi, with 10 operators per locality. NTFP traders were polled in the Kalehe's two markets, with 15 traders per market. Consumers were chosen not only from the markets where trader surveys were conducted, but also from their homes. Depending on the respondent's status (harvester, trader or consumer), information was collected on the products exploited, the impact of anthropic pressures on the sustainability of NTFPs, their origins, their prices, the satisfaction of supply and demand, the frequency of purchase, harvesting constraints, sellers' constraints.

Table 1. Socio-economic characteristics of the people surveyed

Parameter	Modalities	Harvesters (N=70)		Sellers (N=70)		Consumers (N=30)	
		N	(%)	N	(%)	N	(%)
Gender	Male	48	68,6	11	36,7	13	43,3
	Female	22	31,4	19	63,3	17	56,7
Age (year)	Under 20	1	1,4	1	3,3	0	0,0
	21-30	11	15,7	4	13,3	4	13,3
	31-40	17	24,3	7	23,3	9	30
	41-50	19	27,1	6	20	7	23,3
	51-60	10	14,3	9	30	5	16,7
	61-70	8	11,4	3	10	5	16,7
	Over 70	4	5,7	0	0,0	0	0,0

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Civil Status	Married	62	88,6	25	83,3	13	43,3
	Single	8	11,4	5	17,7	17	56,7
House-hold size	Mean ± Standard deviation	7,9±2,6		7,2±2,3		7,3±3,0	
Study level	Bachelor	11	15,7	7	23,3	7	36,3
	Primary School	20	28,6	9	30	9	30
	None	33	47,1	14	46,7	12	40
	Training	6	8,6	0	0	2	6,7

2.1. Data analysis

Data was entered and graphs and figure created in the Microsoft office Excel 2013 spreadsheet and R.4.1.3. Descriptive statistics were performed and focused on the calculation of the frequencies of the parameters related to the qualitative variables. A simple factorial correspondence analysis (FCA) was used in R.4.1.3 to assess the relationship between NTFP use, harvesting methods and organs retrieved. Prior to this analysis, a Chi-square test was performed to see the relationship between these variables.

3. Results

3.1. Inventory of NTFPs, their types of use and organs used

Table 2. List of NTFPs of plant origin inventoried, organ harvested, use and mode of exploitation

Scientific names	Vernacular names	Organs retrieved	Use	Mode of exploitation
Albizia gummifera C.A.Sm.	Mushebere	Bark	Med.[1]	Debarking
Annona senegalensis Pers.	Bombi	Leaf, Bark	Food, Med.	Picking, Debarking
Anthocleista grandiflora Gilg.	Kafundankuba	Leaf	Med.	Picking
Azolla nilotica Decne. ex Mett.	Azolla	Leaf	Med.	Picking
Bambousa vulgaris Schrad.	Mulonge	Thatch	Cons.[2]	Felling
Bidens pilosa L.	Kashisha	Leaf	Med.	Picking
Carapa procera DC.	Bugwere	Bark	Med.	Debarking
Capsicum frutescens L.	Pili pili	Fruits	Food	Picking
Cardamine africana L.	Lujinji	Leaf, Bark	Food	Picking
Carica papaya L.	Papayi	Leaf, fruits, stem bark	Food, Med.	Picking Debarking
Temitomyces sp.	Buyoga	Fruits (Carpophora)	Food	Digging up
Cyathea manniana Hook.	Bishembegere	Leaf	Med., Cons.	Picking
Cymbopogon citratus Stapf.	Majani chai	Leaf	Food, Med.	Picking
Dacryodes edulis H.J.Lam	Bukobe	Endocarp of fruits	Food	Picking
Dioscorea sp.	Masunga	Tuber	Med.	Digging up
Elaeis guineensis Jacq.	Ngazi	Seed pulp, Seve, leaflet and rachis	Food, Med., Cons., Art	Picking, extracting wine

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Ficus glumosa	Mutudu	Fruits	Med.	Picking
Ilex Mitis (L.) Radlk.	Ikenzulu	Fruits	Food	Picking
Khaya grandifoliola C.DC.	Kiba	Bark	Med.	Debarking
Kigelia africana (Lam.) Benth	Musoke	Whole plant	Med.	Picking
Bersama abyssinica Fresen.	Mpari Kaberambasha	Bark, roots	Med.	Picking, Debarking
Maesa lanceolata G.Don	Mpari	Bark	Med.	Debarking
Marattia fraxinea Sm.,	Tshinekeneke	Rhizomes	Food	Digging up
Myrianthus holstii P.Beauv.	Bwamba	Leaf	Med.	Picking
Milicia excelsa (Welw.) C.C. Berg	Muvula	Fruits	Food	Picking
Nephrolepsis undulata (Afzel, ex Sw.) J.Sm.	Tshiragaga	Bulb	Food	Picking
Ekebergia benguelensis (Welw.) ex C.DC.	Sirita	Fruits	Food	Picking
Myristica fragrans Houtt	Noix de mouscade	Roots	Med.	Digging up
Piper guineense Schumach. & Thonn	Kechu	Fruits	Med. Food	Picking
Prunus Africana (Hook.f.) Kalkman	Muhumbahumba	Bark	Med	Debarking
Pteridium aquilinum (L.) Kuhn	Bisirusiru	Leaf	Food	Picking
Raphia sp.	Bubondo	Leaf, leaflet and Rachis	Food, Cons., Art	Picking, extracting wine
Rubus apetalus Poir.	Makerhere	Leaf	Food	Picking
Strombosia schefflera Engl.	Busika	Bark	Med	Debarking
Sida acuta Buem.f.	Sida	Leaf	Med	Picking
Rumex abyssinicus Jacq.	Muberanaga	Bark	Med	Debarking
Symphonia globulifera L.f.	Muzimba	Bark	Med, Art	Debarking
Syzigium guineense Wall.	Mugorhe	Fruits	Food	Picking
Zingiber officinalis Roscoe	Tangauzi	Rhizomes	Med	Digging up
Piptodeniastrum africanum (Hook.f.) Brenan	Lukundu	Bark	Med	Debarking

[1] Medecine, [2] Construction

Fourteen plant-derived NTFPs were identified. The latter are used in food, traditional medicine, construction and art. Plant-derived NTFPs are extracted by picking, debarking, extracting wine, and digging roots (Table 2).

NTFPs are harvested primarily for food and are frequently used as medicine in the study area's traditional medicine. As a result, they are an important source of food on the one hand, and a free source of relief for the treatment of certain diseases on the other. Some

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leaves are also used as ropes and brooms, as well as in the construction of hut roofs (*Cyathea manniana, Raphia sp., Elaeis guineensis*). Debarking, picking, felling, digging up and extraction of wine are the modes of exploitation of NTFPs inventoried in Kalonge. The various modes of exploitation differ depending on the organs harvested. Certain modes of exploitation, such as debarking, digging up, and felling, are however detrimental to the plant's normal growth and can result in its death.

The chi-square test revealed a dependence between the types of NTFP use and harvesting methods (p-value=0.00000001), as well as between types of NTFP use and organs retrieved (p-value= 0.000004). The simple factorial analysis of correspondences (Figure 2) justifies the 73.95 % of linkage between types of NTFP use and organs retrieved and 99.23% of linkage between types of NTFP use and harvesting methods. These variables shows that the fruits, the rhizomes, the leaves and save are more commonly used for food and collected through picking, extraction of the wines and digging up. Barks, tubers and roots are more used in traditional medicine with debarking of barks being the most common mode of collection. Stems are used in arts and thatches in construction, with felling being the primary method of collection.

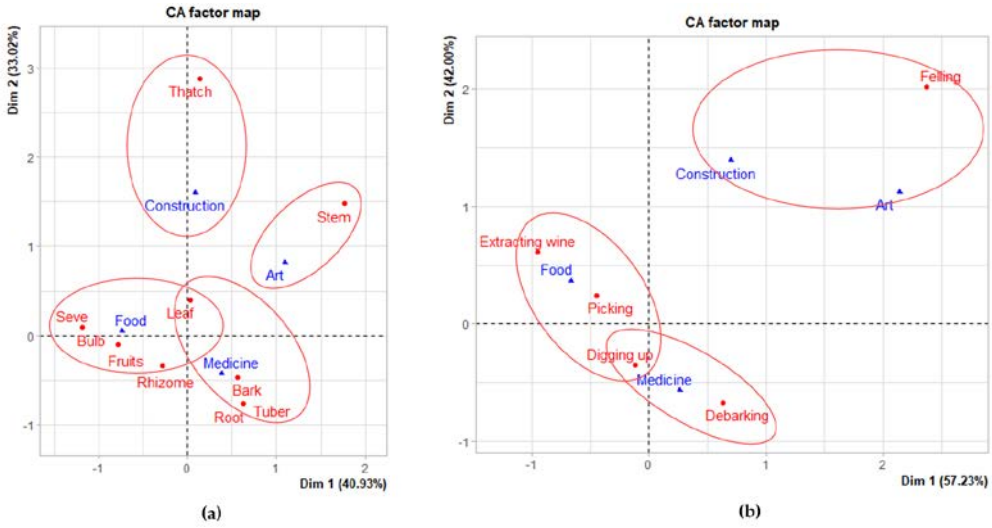

Figure 2. Factorial correspondence analysis (FCA) between (a) types of NTFP use and organs retrieved, (b) types of NTFP use and harvesting methods.

Table 3. List of NTFPs of animal origin inventoried, type of use and mode of exploitation

Scientific names	Vernacular names	Use	Mode of exploitation
Apis mellifera	Asali	Food, Med. [1]	Honey harvesting
Achatina sp	Escargots	Food	Collecting
Potamonautes bayonianus	Mapondo	Food	Collecting
Poelagus marjorita	Nchenzi	Food, Med.	Trapping
Pelusios subniger	Kobe	Food, Med.	Trapping
Cricetomyss gambianus	Mukumbi	Food	Trapping
Bunaeopsis aurantiaca	Milanga	Food	Collecting

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Pantholops hodgsonii	Antilopes	Food	Trapping
Ruspolia differens	Senéné	Food	Collecting
Macrotermes boyonianus	Iswa	Food	Collecting

[1] Medecine

With respect to bushmeat, the proximity of the Kalonge municipality to Kahuzi Biega National Park allows easy access to bushmeat. Among the 10 species of animal NTFPs, some protected animals such as *Pelusios subniger* and *Pantholops hodgsonii* are included (Table 3).

Table 4. NTFPs sold in Kalonge markets

NTFP	Local called	Use	MQS/W	Sales Unit	MSP/SU (USD)	AG/W (USD)
Apis mellifera	Asali	Food, Med[1]	5	Liter	5	25
Bunaeopsis aurantiaca	Milanga	Food	10	Plastic bag of 1Kg	2.5	25
Carica papaye	Papaye	Food	5	A fruit	0.5	2.5
Wild mushrooms	Buyoga	Food	7	Small basin of 5 liters	1.75	12.25
	Kargazoke	Win making	1	Piece	8	8
Cricetomyss gambianus	Mukumbi	Food	5	Kg	3.5	17.5
Dioscorea sp.	Igname sauvage	Food	10	Pile	1	10
Elaeis guineensis	Noix des palmes	Food, Med[1]	15	Small basin of 5 liters	1.25	18.75
	Lungo	Basket	6	Piece	2	12
	Kifagio	Sweeper	20	Piece	0.2	4
	Pombe	Win	30	Liter	0.6	18
	Mawesa	Oil	60	Liter	0.5	30
Macrotermes boyonianus	Iswa	Food	8	Sachet de 1kg	0.5	4
Myristica fragrans	Noix de muscade	Med	10	Plastic bag of 1Kg	0.75	7.5
Parinari excelsa	Kino	Mortar	2	Piece	3.5	7
Pelusios subniger	Kobe	Food	1	Piece	20	20
Piper guineense	Kechu	Med	5	Kg	3.5	17.5
Poelagus marjorita	Nchenzi	Food	5	Kg	3	15
Pteridium aquilinum	-	Food	10	Pile	0.5	5
Raphia sp.	lungo	Basket	6	Piece	0.5	3
	Pombe	Win	20	Piece	0.75	15
	Mulako	-	4	Piece	1.5	6
	Kamba	Rope	30	Meter	0.25	7.5
Ruspolia differens	Senéné	Food	10	Plastic bag of 1Kg	0.75	7.5
Zingiber officinale	Tangauzi	Med	20	Plastic bag of 1Kg	0.75	15

[1] Medecine, **MSP/SU(USD)**: Minimum selling price per sales unit, **MQS/W:** Minimum Quantity Sold per Week, **AG/W**: Approximate gain per week.

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Only 17 NTFPs were found at the markets out of 40 NTFPs of plant origin and 10 of animal origin (Table 4). This is explained on the one hand by the fact that NTFP harvesters are also often consumers. Consequently, some NTFPs do not reach the market and are consumed directly by harverters. On the other hand, harvesters seek a more beneficial market and export some of their products outside of local markets. This is the case for bushmeat like *Pantholops hodgsonii* that is consumed in outlying urban areas.

It was also noted that *Elaeis guineensis* alone gives 5 NTFPs sold on the market while *Raphia spp* gives 4. In terms of minimum sales prices per unit, it was discovered that the product *Pelusios subniger* was marketed at the highest price of 20 USD, followed by the mushroom used in the manufacture of "Kargazoke" juice, which had a minimum price of 8 USD, and honey, which had a minimum price of 5 USD. NTFPs such as sweeper and rope had the lowest sales prices, which were 0.2 and 0.5 USD, respectively. *Piper guineense* and *Myrtica frangran* are processed into powder, *Zingeber offficinalis* is processed into Tangauzi juice, *Apis melifera* is processed into mead, and *Elaeis guineensis* is processed into palm oil.

3.2. Harvesting system and identification of anthropogenic activities that impact NTFP sustainability

Figure 3a shows that 50% of harvested NTFPs is self-consumed, 34.3% commercialized, and 15.7% harvest for commercialization and self-consumption. Harvested NTFP products are sold locally to vendors in Kalonge markets or in urban areas, in this case Bukavu. The majority of these NTFPs are harvested in the natural forests surrounding Kalonge, including the KBNP (60%), woodlands and tree plantations (7%), and trees outside the natural forest and afforestation. Honey is produced under domestication systems in areas near the family hut and accounts for 13% of harvest products (Figure 3b).

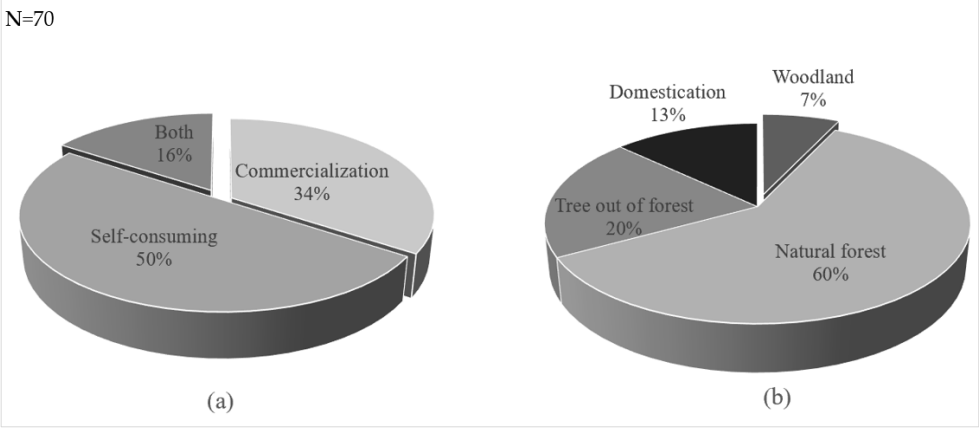

Figure 3. (a) Purpose of the harvest, **(b)** Place of harvest

The primary harvesting constraints reported by harvesters were, in order of importance, species scarcity (34%), and distance from collection sites (22%). Product theft (17%), reduced rainfall (16%), and the short shelf life of certain harvested plant parts in relation to perishability (11%) were also mentioned as constraints to NTFP harvesting (Figure 4a).

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Figure 4b shows that, in addition to the exploitation of NTFPs, some other activities have impacts on forest ecosystems and are at the root of the decline or even extinction of certain NTFPs. This includes charcoal exploitation (43%), energy wood exploitation (24%), artisanal timber exploitation (19%) and agriculture expansion (14%). These anthropic activities also significantly contribute to deforestation and forest loss, especially natural forest, in this case of KBNP.

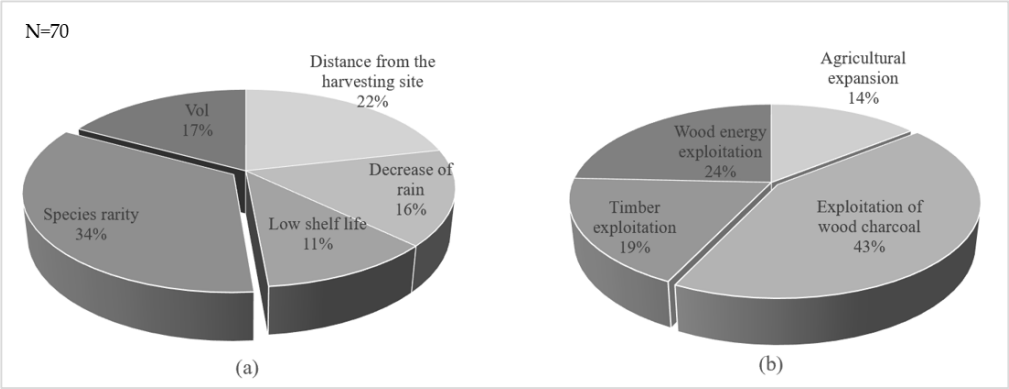

Figure 4. (a) Harvesting constraints, **(b)** Anthropic activities that negatively impact NTFPs

3.3. NTFP consumption and marketing

According to 47% of NTFP sellers, NTFPs are not always available in markets. These vendors claim that NTFPs are more plentiful during the rainy season. As a result, NTFPs are most consumed and used by the local population during this time period. Consumers buy these products based on their personal preferences for the product, such as its nutritional value, process ability, or use in traditional medicine (Figure 5b). The vast majority of NTFP sellers (53.5%) stock up once a week to support their businesses, followed by those who stock up twice a week (30%) and a minority who stock up three times a week (Figure 5b). The supply of NTFPs is determined by the increasing market demand for the products, the nature of the product, and the ease of disposal. Given that, 60% of consumers purchase NTFPs on a regular basis (Figure 5d). These sellers face a number of constraints, including the distance between sales points and harvesting sites, product scarcity, delivery delays, and perishability. This perishability is caused by a lack of NTFP processing in the area (Figure 5a).

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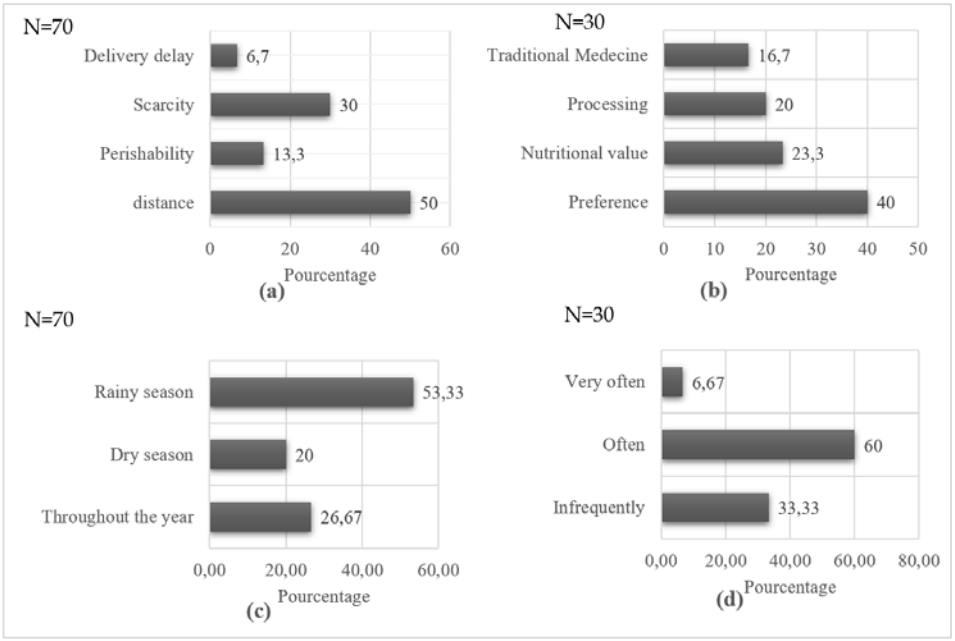

Figure 5. (a) Seller's constraints, **(b)** Reasons for purchase, **(c)** Abundance period of NTFP, **(d)** Purchase frequency

These sellers acquire their products either by purchasing them directly from the harvesters, or they are themselves harvesters, or they are in collaboration with the harvesters. It is therefore possible to establish a local circuit of NTFP supply, demand and consumption from harvest to consumption (Figure 6).

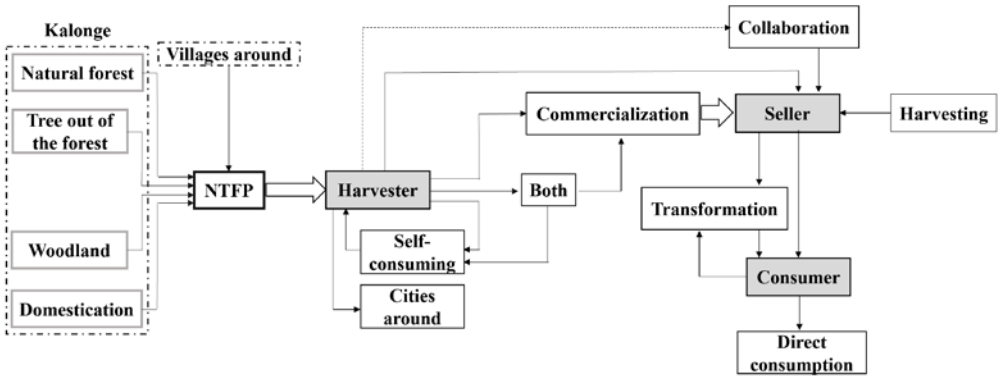

Figure 6. Chain of exploitation, sale and transformation of NTFPs. From harvesting to consumption, several operations are made between the stakeholders involved in the NTFPs chain.

NTFPs in Kalonge come either from different ecosystems in the area (natural forests, tree out of the forest, woodland, domestication), or from ecosystems in neighboring villages. These NTFPs are collected by harvesters who consume part of them, the remaining portion is sent and sold in the towns around Kalonge or sold to NTFP sellers. It should be noted, however, that there is a subset of harvesters who engage in both self-consumption and sale. The sellers obtain their products either directly from the harvesters, through col-

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laboration with the harvesters with specific profit clauses, or by being harvesters themselves. Some of these sellers' process NTFPs prior to selling them, while others do not. As a result, consumers purchase either raw or processed products.

4. Discussion

4.1. Inventory of NTFPs, their types of use and organs used and possible local transformation

This study inventoried 40 NTFPs of plant origin and 10 of animal origin. They are used more as food and in traditional medicine. Indeed, according to World Health Organization studies, wild plants help meet the health and nutritional needs of 80% of people living in developing countries [24,25]. Globally, [26] state that 1.6 billion people worldwide rely on forest resources for a living. In Central Africa, 86 million people live in or near tropical forests [27] and rely on natural resources for a significant portion of their diet [28,29]. [30] also inventoried a diversity of NTFP in Kongo Central province, including products used as food and food additives (edible nuts, mushrooms, fruits, herbs, spices and condiments, aromatic plants, game meat), fibers used in construction, clothing or utensils, resins, gums, and plant and animal products used for medicinal, cosmetic or cultural purposes. The use of medicinal plants is justified by [31] as a lack of essential medicines, inadequate health care, high cost of medicines, and socio-cultural habits pushing people to make herbal medicine a daily activity. [32] add the remoteness of health centers, the high cost of modern health services as the main reasons for using medicinal plants. During Covid-19, [33] demonstrated the importance of medicinal plants in artisanal treatment for the DRC's local population . The species *Maesa lanceolata* has been, for example, used to treat a variety of diseases, including malaria [34], one of the most common diseases in the study setting.

Elaeis guineensis has been mentioned several times because it is a species with many uses. According to [35], *E. guineensis* is used for its sap, leaves, and seeds. The pulp of the seeds is used to make sauces, and the red oil that it produces is also edible. The sap, also known as "palm wine," is drunk as an alcoholic beverage. *E. guineensis* leaflets and rachis are also used to make brushes, baskets, and roofing. The roots of *E. guineensis* are used to treat asthma, and the oil extracted from the kernel of the red nut, known as palm kernel oil, is used in traditional medicine to treat rheumatism and aches. According to the people polled, it is the species that suffers the most from human pressure in the environment, and despite human pressure, the species is still available in all locations, which would be justified by the fact that farmers classify this species in fields and fallows [36].

NTFPs such as Mushroom, *E. guineensis, Zingiber officinalis,* and *Apis melifera* were mentioned several times, reflecting the importance placed on them by the local population. These findings support the assertion that NTFP exploitation is dependent on their availability and accessibility [36], but also on their ability to meet the socioeconomic needs of populations [37].

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4.2. Harvesting system and identification of anthropogenic activities that impact NTFP sustainability

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Plant-based NTFPs are harvested in the form of leaves, barks, fruits, sap, stems, and roots, and the frequency of harvesting is often determined by the needs associated with each NTFP. The same constant was made by [38] for whom barks were more used in traditional medicine. Depending on whether it is one part or another and the size of the individual, harvesters' resort to several modes of removal, some of which are destructive. Indeed, root and bark harvesting may have more negative ecological consequences than fruit or leaf harvesting; however, fruit or leaf harvesting may also have an impact on the natural regeneration process and species conservation [38]. [39] show that using NTFP trees for food, medicine, and root harvesting, increases the likelihood of an NTFP tree absence and the high density of species, and collections of fruit, leaf, and resin decrease the likelihood of an NTFP tree absence. Bark harvesting is more common in woody species [44], and these barks are more commonly used to treat various diseases. The uprooting of the plant has also been observed and would lead to more damage, even the disappearance of certain species in the environments. [40] and [39] mention that the sustainable management of NTFPs must involve an optimal reduction of deforestation by prioritizing improved harvesting methods and local initiatives aimed at the sustainable management of these resources. The organ harvested is also dependent on the use of the NTFP; however, collecting larger quantities can lead to over-exploitation and decreased local abundance; additionally, the extinction of some species that provide highly desired products, as well as intensive exploitation of seeds, fruits, and flowers, can lead to a community's species richness being reduced over time [39].

The vines, stems and trunks are used in construction and crafts. For species where wine extraction is the mode of harvesting, notably *E. guineensis* and *Raphia sp.*, the extraction of forest wine from the inflorescences of *E. guineensis* does not pose major problems for the exploited plants, which are, for the most part, destined for the production of palm oil. *Raphia sp.*, on the other hand, is very harmful to the plant. The method of extraction consists of incising the terminal bud which, after the extraction period, condemns the plant to death [41].

The study also found that the large quantity of NTFPs is harvested in the natural forest, mainly in the KBNP (60%). These findings are consistent with the one of [17] , who discovered that the forest is the primary source of NTFPs. It contains a great biological diversity, including significant quantities of NTFPs useful to humans, as they serve as food, medicine, or intervene in services, and whose importance is no longer to be demonstrated. Harvesters of these NTFPs are either consumers or traders, and as a result, they are an important source of subsistence and income for many farmers [7,38,42].

Apart from NTFP harvesting, some other activities have impacts on forest ecosystems. Charcoal exploitation, wood energy exploitation, agricultural expansion, and artisanal timber exploitation were mentioned as activities that have an impact on non-timber forest products. Among these activities, peasant agriculture is the main cause of deforestation in tropical areas [28,43]. It contributes 35% to forest destruction in Africa, 65% in Latin America, and just over 30% in Southeast Asia. With charcoal and fuelwood being the main cooking fuels in 70% of cities and rural areas in Africa, the high demand for these

 doi:10.20944/preprints202212.0575.v1

fuels is also increasing deforestation and forest degradation and is directly linked to urban population growth [44]. The natural forest around Kalonge, KBNP has been subjected to numerous anthropogenic pressures [45], as well as land use changes that have resulted in significant loss of forest cover and natural resource degradation [43].

4.3. NTFP consumption and marketing

Several NTFPs are sold at the Kalonge markets. This study inventoried 17 NTFPs at the Kalonge markets that could generate an approximate flow of US$ 313 of profit per week. In the Democratic Republic of Congo, NTFP exports were valued as long as at USD 1,120.98 in 2000, compared to US$ 3,432.94 in 1992. In Central Africa, NTFP exports are estimated at 3,475 tons per year [46]. According to FAO, NTFPs contribute US$ 88 billion annually, with a growth rate of 15-25%, and demand is expected to exceed US$ 5 trillion by 2050 [60]. The NTFP sector is therefore becoming increasingly attractive because, in addition to the numerous applications and uses, it does not necessitate large investments.

However, the contribution of NTFPs to household income is highly variable [47] depending on the main activity of the household, the origin of the NTFP, and the stage at which the household is involved in the marketing chain. The NTFP trade seems therefore to be a secondary activity to agriculture [48], which is dominant in the study area. The selling prices of these NTFPs also vary according to demand and availability. [49] consider the main limit to the NTFP sector in Africa are price volatility, insecure and irregular transportation, difficult communication, negative social connotation of the activity, irregular production of resources, and low processing.

5. Conclusions

Several conclusions can be drawn from this study: NTFPs play an important role in the community life of the Kalonge population.This population relies on NTFPs (40 of plant origin and 10 of animal origin) to meet basic needs, primarily as medicine and food. A number of other applications have been mentioned by the populace, including building homes and creating works of art. The applications and harvesting techniques for NTFPs are diverse and tailored to the plant part. As a result, fruits and rhizomes are more commonly used in food, with picking and extraction being the primary mode of collection. Barks, tubers, and roots are more commonly used in traditional medicine, with barking being the primary mode of collection. Stems are used in construction and handicrafts, with felling being the most common method of collection. However, some techniques (debarking, digging up, and felling), are destructive and do not ensure sustainable exploitation. NTFP products are mainly obtained from the natural forest KBNP but also in the woodland, trees grown outside of forest or through domestication. Their abundance, however, is hampered by the extraction of wood for charcoal, energy, and timber, as well as agricultural expansion. NTFPs are abundant during the rainy season and are purchased based on consumer preferences, such as nutritional value, ability to be processed, or traditional medicine use. Harvested products are sold on the market, either raw or processed. The movement of these products between producers, sellers, and consumers in Kalonge is highly complex, necessitating a quantitative study of the NTFP value chain in order to highlight its economic importance at the local level.

Author Contributions: M. M. S., N. B. J. and B.A. conceived and designed this study. N. B. J. did the fieldwork. M. M. S. and D.I.M. product the first manuscript. I.M.G., B.A., C.N.L. review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: Not applicable

Institutional Review Board Statement: Not applicable

Data Availability Statement: Not applicable

Acknowledgments: We would like to thank Mr. Laurent Kidinda Kidinda who helped us with the translation into English of this paper and the substantive corrections

Conflicts of Interest: The authors declare no conflict of interest

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