

Working Paper

Growth Potential and Sustainability of Economically Important Rattan Species in Agro-Ecological Zones of Cameroon

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About this Working Paper

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LIST OF ABBREVIATIONS

AEZs	Agroecological Zones
AfDB	African Development Bank
CSO	Civil Society Organizations
F CFA	Central African Franc
FAO	Food and Agricultural Organisation
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IFAD	International Fund for Agricultural Development
IMF	International Monetary Fund
INBAR	International Bamboo and Rattan Organisation
IRAD	Institute of Agricultural Research for Development
IUCN	International Union on Conservation of Nature
LC	Least Concern
m.a.s.l	Meters above sea level
MINEPAT	Ministry of Economy and Regional Planning
NTFP	None-Timber Forest Product
SPSS	Statistical Package for Social Sciences
USD	United States Dollar
WWF	World Wild Fund for Nature

EXECUTIVE SUMMARY

Rattan is an important Non-Timber Forest Product (NTFP) that plays an important role in the livelihood sustenance of harvesters within communities, but there is little knowledge on its growth potential and sustainability in Cameroon. This study evaluated the growth rate of rattan, its management and harvesting methods for the sustainable development of the rattan sector in Cameroon. Data were collected from the different Agroecological zones (AEZs) (IRAD's classification) in Cameroon. In addition to questionnaires administered to 117 rattan harvesters in four AEZs (2, 3, 4 & 5) (according to literature rattan is absent in AEZ 1), focus group discussions were carried out in each community (25 villages) visited during field survey. Informants led investigators to visit harvesting sites, to identify rattan species, habitats and collect specimens for identity confirmation, using relevant identification tools. GPS coordinates were collected for economically important rattan species. ArcGIS and SPSS software were used respectively to produce rattan distribution maps and to run logistic regression to determine the determinants of the willingness to plant rattan and the frequency of rattan harvesting. The results showed that the north limit of rattan distribution is the Southern part of the Adamawa plateau. *Eremospatha macrocarpa* was found in all of the AEZs surveyed. This was followed by *Laccosperma secundiflorum* and *Laccosperma* in all but AEZ2. *Calamus deerratus* was found in AEZs 2 and 5 and *Eremospatha wendlandiana* was encountered only in AEZ 4. The current conservation status of the economically valuable species of rattan showed that they are of Least Concern (LC) in the national and international levels according to IUCN red list, but were locally threatened by overexploitation due to pressures from market demands, habitat loss due to agricultural expansion, bush fires and timber exploitation. Rattan harvesters opined that small diameter rattan (*Eremospatha* and *Calamus*) and large diameter rattan (*Laccosperma*) take 2-3 years to attain maturity in all AEZs. Small diameter rattan: *E. macrocarpa* growth rate per year in AEZ 2 & 3 is 1-2m; in AEZ 4 it is 5-6m and in AEZ 5 is > 6m. *E. wendlandiana* in AEZ 4 grows 5-6m per year; *C. deerratus* in AEZs 2 grows 1-2 m per year and in AEZ 5, it grows 3-4 m per year. Large diameter rattan: *L. secundiflorum* and *L. robustum* possess similar annual growth rates in the different AEZs. 1-2 m per year in AEZ 3 & 4, >6 m in AEZ 5. *E. macrocarpa* is suitable for expansion all study AEZs (2, 3, 4 & 5); *E. wendlandiana* is suitable only in AEZ 4; *L. secundiflorum* and *L. robustum* are suitable for expansion in AEZs 3, 4 & 5; and *C. deerratus* is suitable in AEZs 2 & 5. Rattan management is traditional. State and customary regulatory instruments are available, although not effective in all the different AEZs. More than 95 % of rattan was harvested from the wild. All harvesters have the willingness to plant rattan on farms ($P < 0.10$), with main determinants of their willingness being household size ($P < 0.05$) and availability of market for rattan ($P < 0.10$). This study provided baseline information for policymakers to formulate development policies in favour of rattan expansion and sector development in Cameroon.

1. INTRODUCTION

1.1. Background

Rattans are species of spiny climbing palms that belong to family Arecaceae (Palmeae) and subfamily Calamoideae. There are 11 genera, 631 rattan species reported in Asia-Pacific and Africa (Vorontsova et al., 2016). The genera concerned are *Calamus*, *Eremospatha*, *Korthalsia*, *Laccosperma*, *Myrialepis*, *Oncocalamus*, *Plectocomia* and *Plectocomiopsis*. *Eremospatha*, *Laccosperma* and *Oncocalamus* are restricted to Africa, while the remaining genera are distributed throughout the Asia-Pacific region (except one African species of *Calamus*) (Vorontsova et al., 2016). Indonesia possess the highest number of rattan species in the world accounting for over 300 species, and make up 80 – 90 % of the total global rattan production (Bastian²⁰¹³). This makes Indonesia the leading country in harvesting and exportation of rattan (FAO, 2011). Rattans can be found in diameters between 3 mm to 20 cm and are divided into small and large diameter canes (Dransfield, 2002). Both are used by locals for daily commodities and used for many things including but not limited to the making of furniture, household items, baskets and even bridges.

The position of rattan on the world market is expanding due to increasing demand for environmentally friendly products in Europe and United States. The world's rattan sector is estimated to generate a global revenue of USD 10 billion annually (Gonmadje et al., 2018a). In Africa, throughout the lowland tropical forest zone, the climbing palms, or rattans form an integral part of subsistence for many rural populations and provide the basis of a thriving cottage industry (Sunderland, 2001). In this regard, African rattans had long been recognised by donor agencies and national governments as having a potential role to play within the domestic and regional Non-Timber Forest Product (NTFP) sectors, as well as within the significant global rattan market. As increased interest is being shown in the potential role of such high-value NTFPs to contribute to the paradigm of conservation and development, rattan has been one of the often-mentioned products that could be developed and promoted in a meaningful way (Sunderland, 2001).

In Cameroon, Decision No. 0209/D/MINFOF/CAB of 26 April 2019 classifies special forest products and Non-Timber Forest Products (NTFPs) under which rattan is classified in category B being forest resources less threatened in the National Territorial forests. Sunderland (2001; 2012) reports the presence of 22 rattan species in West and Central African Region. Of these known species, 19 occur in Cameroon (Gonmadje et al., 2018a). The *Laccosperma secundiflorum*, *L. robustum*, *Eremospatha macrocarpa*, *E. wendlandiana* and *Calamus deerratus* (used in the absence of more desirable ones) are regarded as the main commercial species of rattan in Cameroon (Gonmadje et al., 2018a). Studies on rattan diversity, distribution, biophysical

and value chains have been widely undertaken in Cameroon but not across all agro-ecological zones (AEZs).

1.2. Objectives

This study seeks to understand the growth potential of economically important rattan species in four (04) agro-ecological zones of Cameroon where rattan thrives.

Specific Objectives:

- Study and depict the growth pattern (growth rate, bio-physical interaction in the ecosystem) of rattan species per agro-ecological zone (AEZ) in Cameroon,
- Estimate sustainable harvesting yield and necessary measures for the sustainable management and harvesting.

2. MATERIALS AND METHODOLOGY

2.1. Study Area

This study was carried out in four of the five agroecological zones (AEZs) of Cameroon. Cameroon is located between Latitude 2° N to 13° N; Longitude 8° 25° E and 16° 20° E in the Central African sub region. It opens to the Atlantic Ocean in the West with a total coastline of 402 km. It is bounded to the west by Nigeria, North-east by Chad, South by Gabon, Congo and Equatorial Guinea and to the East by Central African Republic. It has a total surface area of 475 650 km (MINFOF, 2018).

2.1.1. Agro-ecological Zones (AEZ)

The country is highly ecologically diverse and is described as “Africa in miniature” (MINEPDED,2017). According to the Ministry of Economy and Regional Planning (2015), broadly, the country can be divided into five zones: 1) Agroecology Zone 1 (AEZ1): this zone is composed of a Sudano-Sahelian zone of savannah (19.8% of the country) where a more or less arid climate prevails; 2) Agroecology Zone 2 (AEZ2): This is the Sudano-Guinean high savannah zone (19.8% of the country); 3) Agroecology Zone 3: Western highlands area (8.2%). This AEZ is made up of the entire West and North West Regions of Cameroon as well as parts of the littoral and south-west regions. They are located on the Western highland with a vegetation of montane forest and savannah; 4) Agroecology Zone 4: A monomodal rainfall forest area (12.3%) consisting of dense forests with a humid equatorial climate, covering the Southwest (4.3%), the Coast (3.4%), part of the South (3.7%) and a tiny portion of the Centre (0.7%); and 5) Agroecology Zone 5: a bimodal rainfall forest area (39.9% of the country), composed of humid tropical forests, with a

particularly dense hydrographic network, extending over the East (20.7%), the Centre (12.3%) and the South (6.4%).

2.1.2. Climatic Characteristics and Relief of the Different Agroecological Zones of Cameroon

The climate and relief of the different AEZs of Cameroon are summarised in Table 1.

Table 1: Precipitation, elevation and temperature range with respect to AEZ of Cameroon

	AEZs	Rain fall (mm)	Elevation (m.a.s.l.)	Mean annual temperature (range)
AEZ1	Sudano- Sahelian zone	500-900	250-500	28°C (7.7)
AEZ2	Sudano-Guinean high savannah zone	1500-1800	500-1500	23°C (6.4)
AEZ3	Western Highlands zone	1800-2400	1500-2500	21°C (2.2)
AEZ4	Monomodal rainfall forest zone	2000-11000	0-500	26°C (2.8)
AEZ5	Bimodal rainfall forest zone	1500-2000	400-1000	25°C (2.4)

Meters above sea level (m.a.s.l) Source: (Toukamet al., 2009; IRAD, 2005)

The vegetation of Cameroon varies with respect to the different phytogeographical distribution described by Letouzey (1985) (Figure 1).

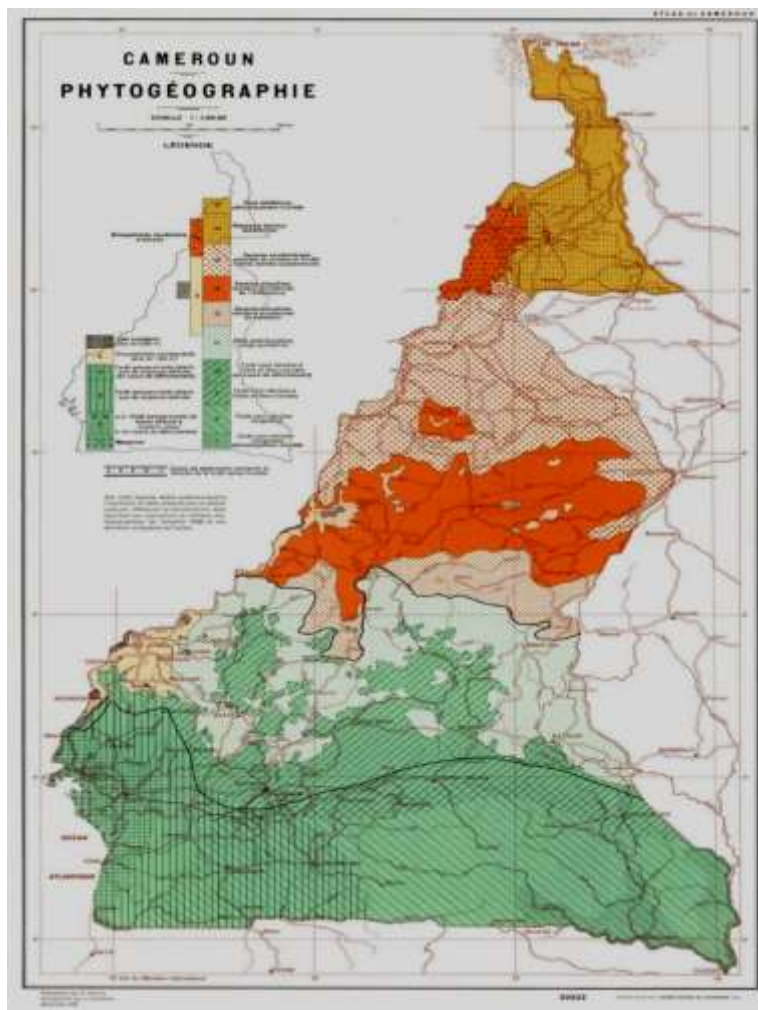


Figure 1: Map of phytogeography of Cameroon (Adapted from Letouzey, 1985)

2.1.3. Sampling Site

This study selected commercialised rattan species and their production zones within the different AEZs for sampling, with the exclusion of the Far North, North West, South West due to insecurity. AEZ1 was left out because it is entirely in the Sudano-Sahel zone which is dry and out of rattan habitats range. Sampling sites included the following: Mbigoro I, Batoua Pangar, Dobiri, Mbella, Bindiba and Sourma in Dir Sub Division, Mbere Division of Adamawa (AEZ2); Magba, Malentouen and Massangam Sub Divisions in the Noun Divisions of West Region (AEZ3); Campo, Kribi 1 and Lokoundje sub-Divisions in Ocean Division of the South Region; Edea in Sanaga Maritime Division and Douala 3 in the Wouri Division of Littoral Region (AEZ 4). In AEZ 5, sampling took place in Mbalmayo Sub Division (in Zamakoe, Yup, Ndik and Abang villages) and Ngambe Tikar Sub Division of Centre Region; Abong Mbang Division, Dimako Sub Division, Bertoua 1 Sub Division, Batouri Sub Division, Belabo Sub Division of East Region of Cameroon. (Figure 2).

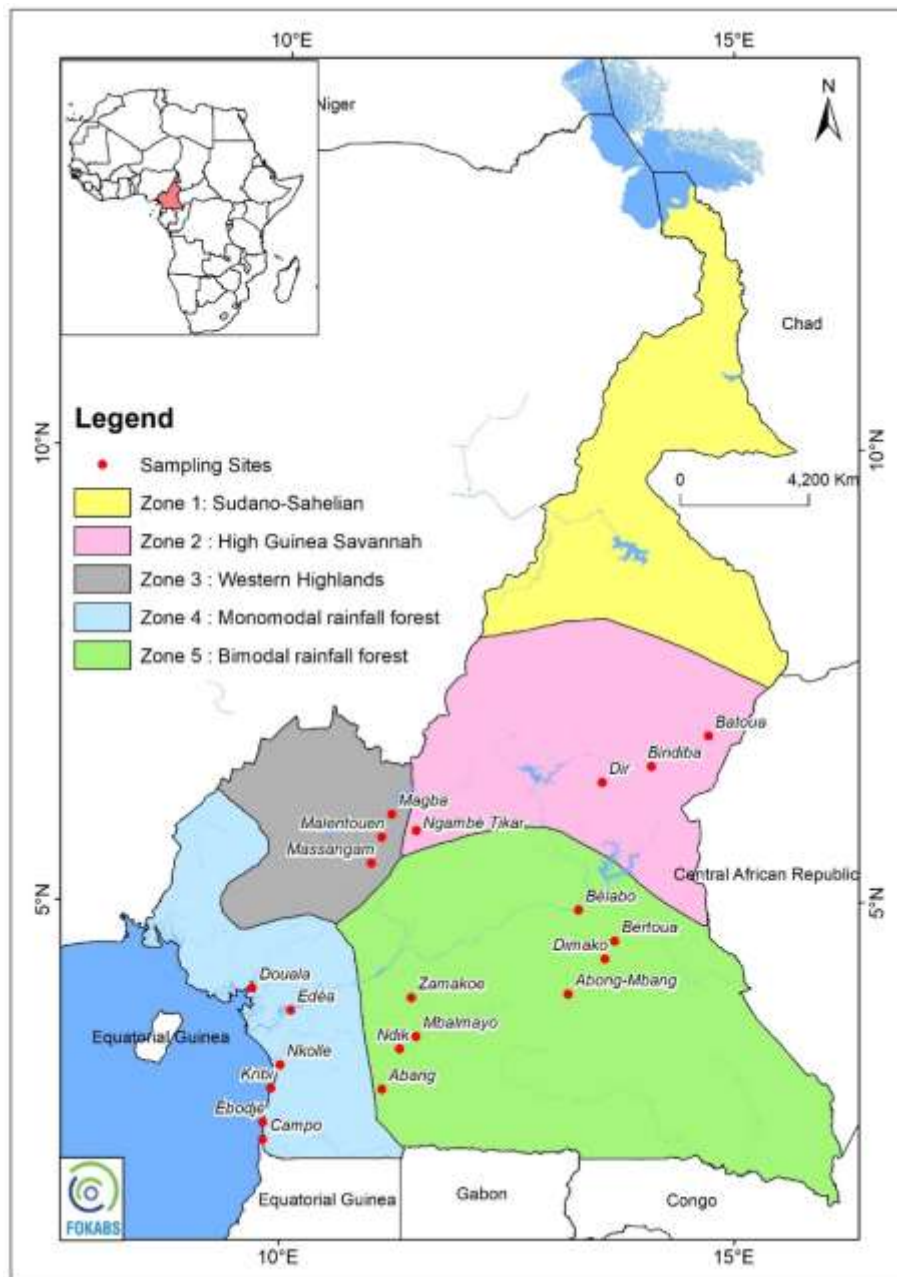


Figure 2: Map agroecological zones and study site

2.1.4. Biophysical Environment of selected area for this study

The biophysical environment of the different areas selected for the survey is presented in Table 2.

Table 2: summarise the biophysical environment of the study area selected for the survey

Study area	Climate	Temperature (°C)	Rainfall (mm)	Humidity (%)	Seasons	Altitude (m)	Soil types	Vegetation type	Relief	Hydrography	References
Agroecological Zone 2											
Dir	Sudano-Guinean type	20 -36	-	-	2 *	800 -2000	Hydromorphic and ferralitic soils	Sudano-Guinean savannah: forest galleries, open forests with wooded savannah, wooded savannah, shrubby savannah and grassy savannah	undulating peneplain and small hills	Djerem	PCD Ngaundal, 2014; PCD Meiganga, 2013; Letouzey, 1985
Agroecological Zone 3											
Malantouen	Transitional Equatorial and Tropical Sudano-Guinean type	27.5	539			1100	Granite and alluvia soils	Woody savannah and some gallery forests	Montagne, large plain and Valley	River Mbam and streams: Miepouen, Mape, Nshi and Mih	PCD Malantouen, 2011; Letouzey, 1985
Massangam	Humid tropical forest		1883, 56	23.57			Laterite brick red	Savannah Grass land	Large plain	Koukep, Kouotcham, Magna, Mfoù, Ndouop, Kouyam, keunké, Bouré, Folé, Mabouo, Nguigouo, Melap, Rou, Bakoup, kie-fon, Mazem	PCD Koutaba, 2014; Letouzey, 1985
Agroecological Zone 4											

Campo	Classical Guinean Equatorial type	25	2 685 mm	73	4 *	13- 1020	vertisols and ferralitic soils	Biafran and Atlantic coastline types both rich in Caesalpinaceae	coastal lowlands	Ntem, Biwome, Ndj'oBitande, Nyavarega, Mvasse, Lobe and Memvele	PCD Campo, 2014 Letouzey, 1985
Kribi 1	Equatorial Guinean type	25	1800 - 2000	75	4	20 – 300	Ferralitic and hydromorphic soils	Evergreen, hydrophilic and dense equatorial rain forest	Relatively flat to accidental land	Kienke, Lobe, Niete, Tyangue	PCD Niete, 2013; Letouzey, 1985
Lokoundje	Equatorial and classical Guinean type with maritime predominance	12 - 50	700	n/a	4	n/a	Ferralitic, Topomorphic and orthotics	Biafran and Littoral forests	Coastal lowlands and plateaux	Sea, Lobe and Nyong	PCD Looundje Letouzey, 1985
Edea and Douala 3	Tropical Humid	24 - 28	n/a	n/a	2**	2 – 92	Sandy-clay and lateritic type	Forest galleries along watercourses	cliffs at the entrance of Beach and valleys	Ossa, Sanaga, Mbongo, Mbanda, Kwakwa and Ndigle	PCD Dizangue, 2011; PCD Dibamba, 2012 PCD Dibombari, 2012; Letouzey, 1985
Agroecological Zone 5											
Mbalmayo	Guinean Equatorial type	19.3 – 31.5	1900	67.5 - 82	4 *	13- 1020	Hydromorphic and ferralitic soils	Forest, rich in marketable species and Non-Timber Forest Products (NTFPs)	undulating peneplain and small hills	Nyong, So'o	PCD Mbalmayo, 2019; Letouzey, 1985

AbongMbang	Equatorial Region	23 - 26	1600 - 2000	n/a	4	600	Ferralitic and lateritic red clayey soils	Semi-deciduous dense Forest	undulating	Nyong	PCD AbongMbang, 2012; Letouzey, 1985
Dimako	Guinean Equatorial type	n/a	1 500	n/a	4	600	Ferralitic, Hydromorphic in marshy valleys	Green Equatorial Forest and <i>Ombrophilic</i> and Strewn with Fallow land	Plateaux shallow and risk zones	Doume, Djo	PCD Dimako, 2011; Letouzey, 1985
Bertoua	Guinean Equatorial type	n/a	1500	n/a	4	600	Ferralitic, Hydromorphic	Green Equatorial Forest and <i>Ombrophilic</i> and Strewn with Fallow land	Plateaux shallow and risk zones		Letouzey, 1985
Belabo	Guinean Equatorial type	20 - 30	1 816.1	n/a	4	500 - 800	Majority Ferralitic and sandy clay or silty clay soils, hydromorphic soils in the valleys	Guinean Congolese: Semi-caducifoliated humid dense forest	little accidental	Sanaga	PCD Belabo, 2012; Letouzey, 1985
NgambeTikar	Guinean Equatorial type	23 - 24	1 600	n/a	4		Ferralitic soils	Semi-caducifoliated forest and woody Savannah	generally flat and very little unevenness	Mbam, Nguien, Djie, Mpem, Nwing, Kieng, and Hong.	PCD NgambeTikar, 2013; Letouzey, 1985

*2 dry seasons and 2 wet seasons; ** 1 dry season and one wet season

2.2. Methodology

2.2.1. Desk Review (Secondary Data Assembling)

Extensive literature from grey and published data on rattan in Cameroon was reviewed. Emphasis was laid on Rattan Value chain analysis in Cameroon, the Taxonomy, Ecology and Utilisation of African rattans and a taxonomic revision of the rattans of Africa (Sunderland 2001; Sunderland, 2012).

In addition, literature on Natural Regeneration Population (Titi & Prameswari, 2018); and natural growth rates of economically important species of rattan were reviewed. This complemented information obtained during field survey on the growth and habitats of rattan in Cameroon; economically important rattan species; yields of Rattan in Cameroon; annual growth potential of the rattan species.

2.2.2. Primary Data Collection

General tools such as participant field survey, informant interviews, standard questionnaires, rattan specimens and GPS were used for primary data collection.

Distribution of Economically Important Rattan Species

Field inventory for commercialised rattan was carried out in Cameroon, with respect to the different AEZs. Informants (primary harvesters) accompanied investigators to harvesting sites for preliminary identification of commercial rattan. Specimens and clean photographs of unidentified species were collected with the help of a pruning shear and a camera respectively. The taxonomic revision of the rattans of Africa (Arecaceae: Calamoideae) (Sunderland, 2012) was used to complete the identification. GPS coordinates were recorded from the field and completed from the taxonomic revision of the rattans of Africa (Sunderland, 2012). The distribution of commercial rattan species in Cameroon was established.

Description of Economically Important Rattan Species

Brief description of the different commercial rattan was undertaken with the support of images pictures from the field survey and diagrams of the plants from the taxonomic revision of the rattans of Africa (Arecaceae: Calamoideae) to complement the field data (Sunderland 2001; Sunderland, 2012).

Current Rattan Conservation Status

The commercial rattan species were compared with the IUCN (2020) red list for international level and Onana (2011) for national level; to describe the conservation status of the different species in Cameroon.

Habitat

Information on the rattan ecological niche was recorded to describe their habitats in Cameroon. Sunderland (2012) was used to complement the information of rattan species habitats in Cameroon.

Growth Pattern of Rattan Species in different Agro-ecological Zones

Semi-structured questionnaires were established to capture information on rattan species commercialised, collection sites, collection season, annual growth rates, harvesting methods, harvesting tools, knowledge of sustainable management. One hundred and seventeen (117) questionnaires were administered to rattan harvesters in the different study area. A focus group discussion was conducted per community (25 villages surveyed) in the study area to identify harvesters and to evaluate traditional and state implications on the management of rattan stocks.

Site Suitability for Expansion

Based on the results on commercial rattan species and habitat preference in Cameroon and good practices, site suitability was proposed base on the rattan natural habitats.

Management and Harvesting Options

Information from harvesters, informants and management strategies elsewhere were exploited to propose management in natural stands, plantations, and agroforestry context and harvesting options in Cameroon.

Yields of Rattan in Cameroon

The harvester's views, the exploitation of FAO (2002), FAO (2005) and other literature provided the sustainable harvesting yields and harvesting methodologies.

2.3. Data Analysis

Data was coded in an excel sheet, processed and transferred into SPSS software where descriptive and inferential statistics were performed. Logistic regression was computed to determine the determinants of willingness to plant rattan and the frequency of rattan harvest in the study zones. Chi square and Kruskal Wallis tests were used to compare harvester's perception on rattan across the different AEZs. Results were presented in text, figures and tables.

3. KEY FINDINGS

3.1. Distribution of economically important rattan species in the different AEZs of Cameroon

3.1.1. Rattan Species Identification and Distribution in Study Area

The inventory results of the commercialised rattan species in the different localities visited during this study showed that the species *Eremospatha macrocarpa* is found in all the different AEZs. This was followed by *L. secundiflorum* and *L. robustum* (large diameter cane) found in all AEZs except AEZ2. *Calamus deerratus* was found in AEZs 2 and 5 and *E. wendlandiana* was encountered only in AEZ 4 (Table 3).

Table 3: species identification and distributions in Cameroon

AEZs	Regions	localities	Rattan Species
2	Djerem, Adamawa	Dir	<i>Calamus deerratus</i> , <i>Eremospatha macrocarpa</i> ,
3	Noun, West	Magba Malantouen, Massangam	<i>Laccosperma robustum</i> , <i>Eremospatha macrocarpa</i> , <i>Laccosperma secundiflorum</i> ,
4	Ocean, South Sanaga Maritime and Wouri, Littoral	Campo, Kribi 1, Lokoundje, Edea, Douala 3	<i>Laccosperma secundiflorum</i> , <i>Eremospatha macrocarpa</i> , <i>Laccosperma robustum</i> , and <i>Eremospatha wendlandiana</i>
5	East	Abong Mbang,	<i>Laccosperma robustum</i> , <i>Eremospatha macrocarpa</i> , and <i>Laccosperma secundiflorum</i>
		Dimako	<i>Laccosperma robustum</i> , <i>Eremospatha macrocarpa</i> , and <i>Calamus deerratus</i>
		Belabo,	<i>Laccosperma robustum</i> , and <i>Eremospatha macrocarpa</i>
		Bertoua East	<i>Laccosperma robustum</i> , and <i>Eremospatha macrocarpa</i>
	Nyong et So'o and	Mbalmayo,	<i>Eremospatha macrocarpa</i> , <i>Calamus deerratus</i> , <i>Laccosperma robustum</i> , and <i>Laccosperma secundiflorum</i>
	Mbam et Kim, Centre Region	Ngambe Tikar	<i>Laccosperma secundiflorum</i> , <i>Laccosperma robustum</i> and <i>Eremospatha macrocarpa</i>

3.1.2. Spatial distribution of economically important rattans species in Cameroon

The distribution of economically important rattans species reached their northernmost limit in the Southern Adamawa Region of Cameroon. At the extreme northern limit, it is possible that they may occasionally be subjected to temperature range of 20-36 ° Celsius. In altitudinal range rattan thrives at an altitudinal range

between 800 to 2000 m. Moving Southwards, rattan distribution in species diversity and density increase toward the sea level (Littorals). Precipitation (rainfall) that favour rattan varies from 539 – 2,685 mm. Climate vary from Classical Guinean Equatorial, Guinean Equatorial (AEZs 4 and 5), tropical humid to Sudano Guinean types (AEZs 2 and 3) constituting broadly the Guineo-Congolian evergreen forest (Table 2), from the coast in the Southern part of Cameroon (South and Littoral) to the extreme northern limits of rattan distribution in the Adamawa.

The map (Figure 3) represents the geographical distribution of economically important rattan species in Cameroon.

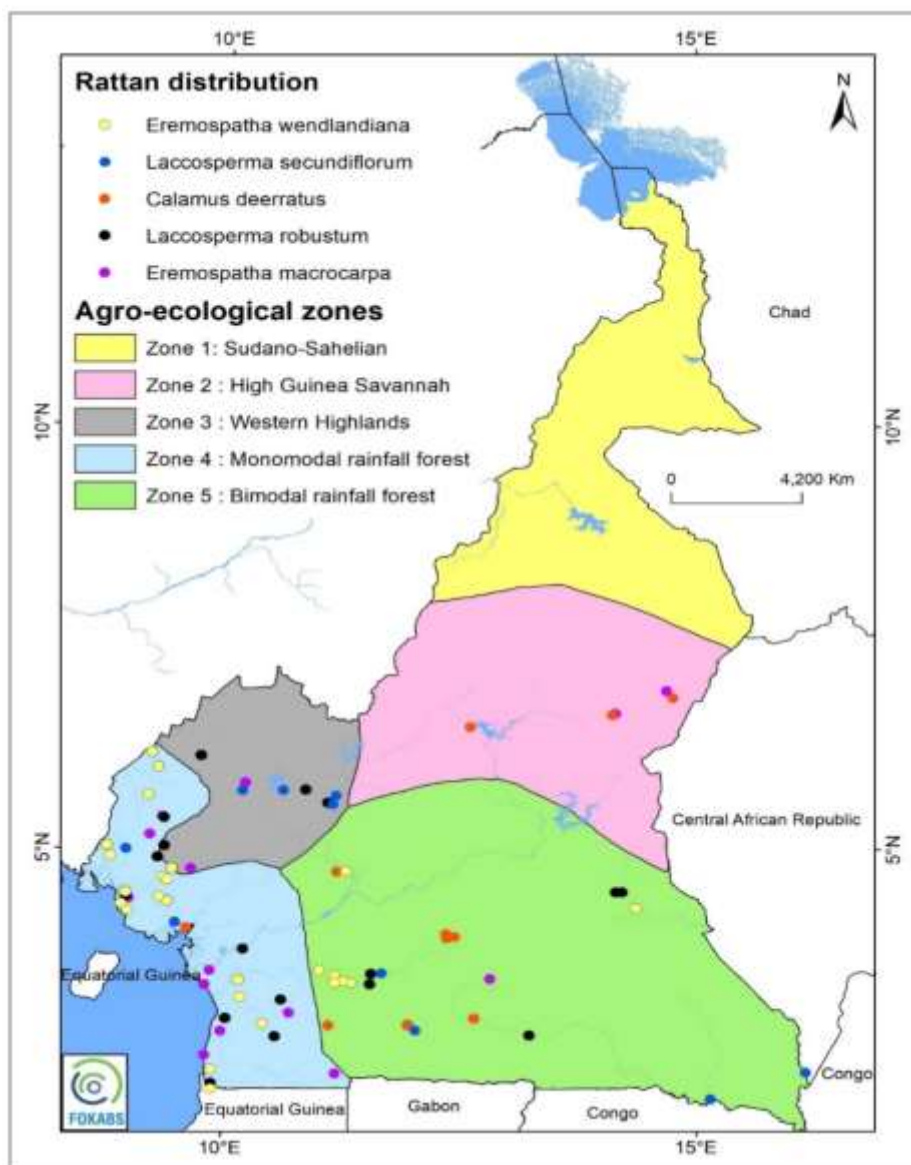


Figure 3: Map of distribution of economically important rattan species in Cameroon

The distribution per economically important rattan species is as follows:

***C. deerratus*' distribution in Cameroon**

Calamus deerratus is the most widely distributed across the humid forest zone of Africa; from the Gambia and Casamance in Senegal, southwards to northern Angola and Zambia and eastwards to southern Sudan and Uganda. In Cameroon, it is found in Bezirk Djah BuschenIII; Mungo River Crossing, Buea-Douala at Uham, Limbe-Douala road at Mungo Bridge in AEZ4; Tibati in AEZ2, Cameroon River, South East Ambam along the river Kye, Northeast de Bafia), gallery forest on river Mbam, Ebolowa, Sangmelima northeast of Moloundou, in AEZ5.

***E. wendlandiana*'s distribution in Cameroon**

E. wendlandiana is distributed from South East Nigeria to Gabon, commonly in coastal forest, although with outliers present in the swamp forests of the Central African Republic. In Cameroon, it is found in Mile 40, Buea-Kumba road, Southern Bakundu, Onge, North East of Kribi, Nkongkengui, North East of Makak, Mintom I, 70 km East of Djoum, Edea-Kribi road near Elogbatindi, east of Kribi, Southern Bakundu Forest Reserve, Barombi, Kembong Forest Reserve, South West Province, Kumba, Korup National Park, Mokoko River Forest Reserve, Southern Bakundu Forest Reserve, Onge River valley north of Mamfe, Campo Ma'an National Park, Obonyi I and Idenau.

***E. macrocarpa*'s distribution in Cameroon**

E. macrocarpa is a very widespread and is distributed from Senegal in West Africa through to the lowland forests of the Congo Basin. In Cameroon, it is found in Tissongo, Lac Tissongo, 16 km East South of Mouanko, Buea-Kumba road, Mungo River Crossing, Mount Kupe, Kribi-Ebolowa road, 34 km West of Nguti, 35 km West of Nguti, 10 km South East of Sangmelima, North of Nguti, Sangmelima, Dja Forest Reserve, Nguti, Southern Bakundu Forest Reserve, Onge River valley, Kumba to Mamfe road, 30 km north of Mamfe, Rumpi Hills Forest Reserve, Limbe-Kumba road: Mile 40, Campo Ma'an National Park, 20 km south of Kribi, 30 km south of Kribi, Takamanda National Park, 15 km north of Nguti on Mamfe road, Mokoko River Forest Reserve, 15 km West of Manyemen, Ebom II in the AEZ4 and 17 km in the South West Ambam in the AEZ5.

***L. secundiflorum*'s distribution in Cameroon**

This species is distributed from Senegal to Cameroon south to Democratic Republic of Congo. *L. secundiflorum* is a species of high forest, and is commonly found under a forest canopy. In Cameroon, it is found in Kembong Forest Reserve, South West Region, East, Korup National Park, Banks of Onge River valley, Limbe–Douala road at Mungo Bridge, Takamanda National Park, Mokoko River Forest Reserve,

Sango River, Ngoko river near Pandama, 15 km from Kribi on Campo road in AEZ4 and 8 km ESE of Moloundou in AEZ5.



***L. robustum*'s distribution in Cameroon**

L. robustum is a very common species throughout its range and is distributed from South Eastern Nigeria to the central Congo Basin. This species is commonly encountered in degraded forest zones and regrowth vegetation and responds well to selective-logging activities. It is encountered on both *terra firma* and seasonally-inundated forest. In Cameroon, it is found in Campo National Park, 20 km from Kribi, Limbe to Kumba road, Mile 40, Korup National Park, Near Benga on Douala to Yaounde road, 10 km South East Sangmelima, Edea-Kribi road near Elogbatindi, Njingum 1, Nkakanzock, near Edea, Njingum 3, Bagoran, Njingum 5, Akom II, Njingum, Nguti, Korup National Park, Mokoko River Forest Reserve, Southern Bakundu Forest Reserve, 30 km north of Mamfe, Rumpi Hills Forest Reserve Takamanda National Park, Kribi to Lolodorf road all in AEZ4 and North West Region in AEZ3.

3.2. Description of Economically Important Rattan Species in Cameroon

The different rattan species are *L. secundiflorum*, *L. robustum*, *E. macrocarpa*, *E. wendlandianna*, and *C. deerratus*. The morphological descriptions are presented in Table 4.

Table 4: Description of economically important rattan species

Species	Description (Sunderland, 2012)	Photographs
<i>C. deerratus</i> Mann & Wendl.	<ul style="list-style-type: none"> • This rattan species is a clustered, slender to moderate palm climbing to 20 m, often sympodial branching at the base, • Stem is without sheaths, 1.0–2.8 cm in diameter, with, 1.2–3.5 cm; internodes 8–20 cm long, more commonly 15–20 cm, • Leaf-sheaths varied in armature from almost unarmed to densely spiny, with a distinct horizontal, sometimes folded, knee below the petiole; spines dark brown or black, • Leaves ecirrate, up to 1.75 m long, usually 1.2–1.5 m; petiole to 20 cm long, rounded abaxially, concave adaxially, • Flagellum up to 3.5m long by 4 mm wide at the base, decreasing very gradually above, armed with small recurved thorns, • Male and female inflorescences similar, up to 3.5m long, with 1–4 partial inflorescences and a long terminal sterile flagellum; • Fruit at maturity to 1.5 cm, × 1 cm with a short beak up to 2 mm tipped by remains of the style, with 17–20 vertical rows of scales, and • Seed flattened laterally, $\pm 9 \times 8 \times 5$ mm, with sarcotesta ± 1 mm thick when dry 	 <p data-bbox="1520 813 1818 846"><i>C. deerratus</i> (Field data)</p>
<i>E. macrocarpa</i> (G. Mann & H. Wendl.) H. Wendl	<ul style="list-style-type: none"> • this species is a clustered slender to moderate palm climbing to 50–75 m, rarely to 150 m. • Stems circular in cross-section, without sheaths, 10–18 mm in diameter, with 22–30 mm; internodes 13–16 cm long, • Leaf sheath longitudinally striate, sparsely to moderately covered with light brown scale-like indumentum; • leaflets, up to 25 pairs on each side of the rachis, linear–lanceolate, abruptly contracted at the base, irregularly and narrowly praemorse at apex, • Inflorescence glabrous, up to 55 cm long; peduncle 10–15 cm long; rachis 25–40 cm long, 	 <p data-bbox="1520 1279 1850 1312"><i>E. macrocarpa</i> (Field data)</p>

E. wendlandiana Dammer ex
Becc

- this species is a clustered moderate to robust palm climbing to 60 m;
- Stems \pm circular in cross-section, without sheaths 12–20 mm, with 15–30 mm; internodes up to 30 cm long;
- Leaf sheath only very lightly striate, with sparse to moderate caducous black indumentum; Knee conspicuous, narrowly-linear, up to 5–12 cm long, tapering at base;
- Leaves sessile; rachis up to 2m long, abaxially rounded, adaxially flattened or slightly concave on upper surface, becoming rounded then triangular in cross-section distally; Cirrus up to 2 m long, armed as the rachis, although spines becoming sparse distally, indumentum absent;
- leaflets up to 20 on each side of the rachis, strictly rhomboid or trapezoid with conspicuously straight margins; Concolorous, armed along the margins with 2 mm long, robust, slightly reflexed, black-tipped spines, acanthophylls 2–2.5 cm long, somewhat slender, at 30° angle to cirrus;
- Inflorescence glabrous, up to 80 cm long, peduncle up to 30 cm long; rachis up to 50 cm long, arching, rachis bracts incomplete,
- Flowers borne in close pairs; calyx 2 mm long \times 4 mm wide at the mouth, shallowly 3-lobed;
- Fruit at maturity ovoid to broadly cylindrical, 2.5–3.5 cm \times 1.8–2.4 cm, with 15–19 vertical rows of scales; and
- Seed compressed with, 1.8–2.8 cm long \times 1.2–1.8 cm wide \times ca.1 cm deep.



E. wendlandiana (Field data)

L. secundiflorum (P. Beauv.)

Küntze

- this is a clustered moderate to robust palm, climbing to 25–50 m;
- Stems without sheaths 20–25 mm in diameter; with 30–35 mm; internodes 18–35 cm long.
- Leaf sheath dark green, lightly striate, moderately to sparsely armed with black-tipped finely triangular, upward-pointing or spreading spines;
- sheaths on upper portion of stem more sparsely armed; sparse black indumentum present on mature sheaths; ocrea 25–35 cm long;
- Leaves up to 3.5 m long; petiole 30–60 cm long, 1.5–1.8 cm wide, commonly at 45–60° angle to the sheath and
- leaflets composed of 2–4-folds, 25–40 on each side of the rachis, equidistant, often variable in width, arching from the rachis, not strictly pendulous, sigmoid, elongate, leaflet apex very finely acuminate with tip often breaking off, 35–45 cm long × 3–8 cm broad at the widest point.



L. secundiflorum (Sunderland, 2001)

L. robustum (Burret) J.
Drans.

- this species is a clustered robust palm climbing to 30–45 m;
- Stems without sheaths 30–50 mm in diameter, with 45–60 mm; internodes 35–50 cm long, although more commonly 18–25 cm;
- Leaf sheath moderately to profusely armed with black-tipped finely triangular, upward pointing or spreading spines; sheaths on upper portion of stem more sparsely armed;
- juvenile sheaths particularly profusely armed; dense brown-black indumentum present on mature sheaths, sparser on juvenile sheaths; ocrea 20–30 cm long;
- Leaves up to 3.5m long; petiole 5–12 cm long, 1.5–2.5 cm. wide, mid to dark green with scattered brown-black indumentum, particularly on upper surface; rachis 1.5–2 m long, shaped as the petiole, becoming more trapezoid in cross section then triangular in cross-section distally, armed as the petiole proximally, spines becoming sparser distally;
- leaflets always composed of a single-fold, 45–65 on each side of the rachis, equidistant, opposite to sub-opposite proximally, inequidistant, alternate distally, papyraceous, conspicuously pendulous;
- Inflorescences, numbering 6–12 produced simultaneously in the distal 1.5–2.2m portion of stem; peduncle 12–20 cm long; prophyll \pm 15 cm long; rachis branches up to 50 cm long, perpendicular to the main axis;
- Flowers in dyads, rarely triads, at anthesis \pm 1 cm \times 2.5–3.0 mm wide; calyx \pm 6 mm long, excluding 1–1.5 mm long angular stalk, 2.5–3 mm wide;
- Fruit at maturity ovoid; 1– (rarely 2–) seeded, 1.2–1.5 cm \times 0.8–1.2 cm, with 17–20 vertical rows of scales and
- Seed smooth, ovoid, with lightly scalloped depression on one side, 0.8–1.3 cm long \times 0.6–0.8 cm wide \times 0.5 cm thick.



L. robustum (Field data)

3.3. Current Rattan Conservation Status in Cameroon

All rattan species in Cameroon have low concern (LC) as a status in IUCN (2020) red list¹ (Table 5) and also at national scale according to Onana (2011). However, most of these commercial rattan species are locally threatened due to the expansive exploitation (because of significant increases in market demand), with direct consequence on the preferential habitat loss due to agricultural expansion, bush fire, logging resulting in significant decline in wild rattan stocks.

Table 5: Conservation status of rattan in Cameroon

Rattan species	Level of market demand	IUCN status	Local status
<i>C. deerratus</i>	Very low	LC*	Locally threatened by habitat loss
<i>E. macrocarpa</i>	Very high	LC*	No major threat
<i>E. wendlandiana</i>	average	LC*	No major threat
<i>L. secundiflorum</i>	Very high	LC*	Locally threatened due to habitat degradation and habitat loss (agricultural expansion, high economic value, etc.)
<i>L. robustum</i>	Very high	LC*	Locally threatened due to habitat degradation and habitat loss (agricultural expansion, high economic value, etc.)

*Least Concern (LC)

3.4. Habitat

These rattan species were found in different habitats. Table 6 summarises the different habitat per rattan species.

Table 6: Habitat preferences of the commercialised rattan species in Cameroon

N°	Rattan species	Habitat and ecology according to fieldwork and complemented with Sunderland (2012)
1	<i>C. deerratus</i>	Strong preference for swamp and wet forest
2	<i>E. macrocarpa</i>	Extremely light demanding, occurring naturally in gap vegetation and forest margins.
3	<i>E. wendlandiana</i>	Common component of gap vegetation and forest margins, although it is commonly present in the juvenile form in closed-canopy forest where it occurs.
4	<i>L. secundiflorum</i>	High forest, and is commonly found under a forest canopy
5	<i>L. robustum</i>	Commonly encountered in gap vegetation and regrowth vegetation and responds well to selective-logging activities. It is encountered on both moist tropical forest and seasonally-inundated forest.

¹ Available at www.iucnredlist.org

The Guinean-Congolese forest type of Cameroon is a host to all these different rattan habitats, reason why all these species are present and are under yearly exploitation.

3.5. Growth Pattern of Rattan Species in the Agro-ecological Zones

3.5.1. Biophysical interaction of the economically important rattan species in the different AEZs in Cameroon

AEZ 2

This AEZ 2 is otherwise called High Guinea Savannah covering the Adamawa Region off Cameroon. It is situated on latitude 11°00 and 15°00 E and longitude 5°00 and 8°00 N of the Equator (INBAR and University of Dschang, in press). The climate of this region is the Sudano-Guinean type with two remarkable seasons (dry and wet). The rainfall ranges from 1500-1800 mm per annual, mean temperature of 23°C and altitudinal range of 500-2000 m.a.s.l. (IRAD, 2005, PCD Ngaoundal, 2014). The soils are mostly hydromorphic and ferralitic soils. The relief is undulating peneplain and small hills. AEZ2 is the watershed in Cameroon. All main rivers in Cameroon take their origin from the Adamawa: Djerem, Benue, Sanaga, Nyong, Kadey, Mbam etc. The vegetation is remarkably Sudano-Guinean savannah: forest galleries with open forests with wooded, shrubby and grassy savannahs (Letouzey 1985; PCD Meiganga, 2013). The niche of rattan was the forest galleries with open wooded Savannah. In this zone, the *E. macrocarpa* and *C. deerratus* cohabited the marshes of Dir Sub Division, in the Djerem Division. All *C. deerratus* species was seen in water (swamp) confirming the findings of Sunderland (2012) that this species has a very strong preference for swamp. These gallery forests were open, lighted, and still naturally in vegetation cover. The forest margins were also very prominent since agriculture and grazing activities take place around the zone. This confirms the presence of *E. macrocarpa* which is a species with extreme light demanding, naturally inhabits forest gap vegetation and forest margins (Sunderland 2012). Other main floral diversity with which rattan interact were: *Daniellia oliveri*, *Lophira lanceolata*, *Assogeissus leiocarpus*, *Combretum sp.*, *Isobertina doka*, *Delarium microcrapum*, *Crossopteryx februfuga*, *Sygygium guinense*, *Ficus sp.* Vegetation in fallows included: *Chromoloena odorata* (Bokassa grass) which cover the pastures. This is dominated by Gramineae: *Hyparrhenia rufa*, *Hyparrhenia diplanda* and *Andropogon gayanus* (PCD Ngaoundal 2014).

AEZ3

This zone is found in the Western Highlands: North West and South West Regions of Cameroon. It is situated on latitude 9°00 and 12°00 E and longitude 4°00 and 7°00 N (INBAR and University of Dschang, in press). The climate of this zone generally is the transitional Equatorial and Tropical Sudano-Guinean type with rainfall ranging from 1800-2400 mm, mean annual temperature of 21°C; altitudinal range of 1500-2500 m.a.s.l. This zone has two remarkable seasons (dry and rainy) (Toukam et al., 2009; IRAD,

2005). The soils of this zone are granitic and alluvia soils. The drainage pattern includes River Mbam, Noon, Mezam, Momo, etc. The relief is Montagne (Mt Oku, Mt Bamboutus, Bamenda highlands, Foreke escarment) large plain (Ndop, Santchou, Noon) and Valley (Menchum). The vegetation is woody savannah and some Montagne and gallery forests (Letouzey, 1985; PCD Malantouen, 2011). The rattan species of this zone were *L. robustum*, *E. macrocarpa* and *L. secundiflorum*. Their niches were high forest, and commonly seen under forest canopies (*L. secundiflorum*); forest gaps and regrowth vegetation (*L. robustum*) and gap vegetation and forest margins (*E. macrocarpa*). These rattan species were found interacting with other plant species. The forest is less diversified with the main species such as: *Raphia farinifera*, *Ficus sp.*, *Vitex sp.*, *Arungana madagascariensis*, *Chlorophora exelsa*, *Baillonela toxisperma*, *Entandrophragma cylindricum*, *Triplochyton sceroxylon*, *Terminalia superba*, *Erythrophleum ivorense*, *Sterculia oblonga*, *Picnanthus angolensis*, *Ricinodendron heudolettii*, *Guibourtia demeusei* (Letouzey 1985; PCD Malantouen, 2011; Gonmandje et al. 2018a). The savannah is largely dominated by the Gramineae *Imperata cylindricum* and *Pennisetum purpurum* (PCD Malantouen, 2011).

AEZ4

This zone cuts across four regions (South West, South, Littoral and Centre) around the marine coastal area of Cameroon. It is situated on latitude 8°00 -11°00 E and longitude 2°00 – 8°00 N of the Equator. The climate of this zone cuts across Classical Guinean Equatorial type, Equatorial Guinean type with maritime predominance, Tropical Humid type (Letouzey, 1985). This zone witnessed a rainfall ranging from 2000–11000 mm, with mean annual temperature of 28°C and altitudinal range from 0-4 000 m.a.s.l., (Toukam et al., 2009). This zone has a characteristic of four seasons (2 dry and 2 rainy: Centre, South and Littoral) in some areas and only two seasons in other areas (dry and rainy: South West). The soils are generally ferralitic and hydromorphic soils. Also, are soils like topomorphic, orthotics, sandy-clay, lateritic, volcanic, andosol, vertisol types (PCD Campo, 2014; PCD Dizangue, 2011; PCD Dibamba, 2012; PCD Dibombari, 2012). This zone is the drainage basin to most rivers in Cameroon, Ntem, Nieme, Nyong, Sanaga, Wouri, Mounjo, Nkam etc. All these drains into the Sea and the Atlantic Ocean. The relief cuts across the coastal lowlands, relatively flat to accidental land, plateaux, cliffs at the entrance of beach and valleys, and mountains (Fako). Forest types in this zone include the biafran and Atlantic coastline types both rich in *Caesalpinaceae*, evergreen, hydrophilic and dense equatorial rain forest and Littoral forests (Letouzey, 1985). Rattan is seen in vegetation with main economic floral species such as *Guibourtia ehie*, *Azelia bipindensis*, *Dialium bipindensis*, *Socoglottis Gabonensis*, *Lophira Alata*, *Coula edulis*, *entandrophragma cylindricum* and *Erythrophleum ivorense*. The dominant floral species include *Hallea stipulosa*, *Spondianthus preusii*, *Lasiotiscus manii*, *Plagiosiphon multijugus*, *Gilbertiodendron demonstrans*, *Guibourtia demeusei*, *Sclerosperma manii* and some species of *Uapaca* and *Raphia*. Amongst the NTFP encountered are *Irvingia*

Gabonensis, *Gnetum africana*, *Ricinodendron heudolettii*, *Sclorophoeus zenkeri* and *Garcinia cola* (PCD Campo, 2014; PCD Lokoundje, 2011) and four economically important rattan species: *L. secundiflorum*, *E. macrocarpa*, *L. robustum*, and *E. wendlandiana*.

AEZ5

This zone covers three regions of Cameroon (Centre, South and East). It is situated on latitude 10°23'30'' and 14°00' E and longitude 2°00' and 5°46'50'' N of the Equator. The climate of this area cuts across the Guinean Equatorial type and region. The rainfall ranges from 1500-2000 mm, with an annual mean temperature of 25°C, altitudinal range from 400 to 1000 m.a.s.l. (Toukamet *et al.*, 2009). This zone has a characteristic of four seasons (2 dry and 2 rainy). The soils are mainly hydromorphic and ferrallitic soils. Also associated are lateritic red clayey soils and sandy clay or silty clay soils. Hydrography is characterised by main rivers like: Sanaga, Mbam, Nyong, and Kadey. There are numerous streams and springs. Relief of this zone cuts across undulating peneplain and small hills, plateaux, shallow and risk zones, generally flat and very little unevenness. Vegetation includes forests rich in marketable species and Non-Timber Forest Products (NTFPs), Semi-deciduous dense Forest, Green Equatorial Forest and *Ombrophilic* and Strewn with Fallow land, Guinean Congolese (Semi-caducifoliated humid dense forest) and Semi-caducifoliated forest and woody Savannah. The flora of this zone is characterised into four forest canopy strata: big tree stratum with presence of trees of large sizes, medium trees stratum with the presence of medium size trees and liana species, woody shrub stratum characterised by the dominance of shrubs, and herbaceous stratum characterised by Gramineae (grasses). Floral diversity of importance includes economically important trees: *Terminalia Superba*, *Guiboursia Tessmani*, *Erithropheum ivorens*, *Triplochiton Scleroxilon*, *Distemonenthus benthamianus*, *Baillonella toxisperma*, *Irvingia gabonensis*, *Chorophora excelsa*, *Cylicodiscus gabonensis*, *Piptadeniastrum africanum*; *Pycnanthus angolensis*, *Entandrophragmacylindrica* etc. Herbaceous floral diversity includes *Hyparenia rufa*, *Pennisetum purpureum*, *Musanga cercropiodes*, *Eupatorium* sp, *Imperata cylindricum* and *Chromolaena odorata*, *Ageratum conyzoides*, *Lantana camara*, *mimosaceae*, *Maranthaceae*, *Zinziberaceae* etc. Rattan is mostly encountered in the medium tree stratum characterised by medium trees and liana species (PCD Mbalmayo, 2019).

Rattan species of economic importance were *Laccosperma robustum*, *Eremospatha macrocarpa*, *Laccosperma secundiflorum* and *Calamus deerratus*.

3.5.2. Economically Important Rattan Species Harvested in Different AEZs

Based on the harvester's perception and field validation, the number of economically important rattan species harvested in the AEZ 2 belong to 2 species (*E. macrocarpa* and *C. deerratus*). In AEZ, three species of rattan namely *E. macrocarpa*, *L. secundiflorum* and *L. robustum*) are harvested. Four species namely *E. macrocarpa*, *L. secundiflorum* and *L. robustum* and *E. wendlandiana* are harvested in AEZ4. In AEZ 5, four species of rattan namely *E. macrocarpa*, *L. secundiflorum*, *L. robustum*, *C. deerratus* are harvested. Four out of five AEZs of Cameroon have at least two economically important species which is exploited. These species were found growing in natural forests with the stocks exploited for sustenance use and marketing in Cameroon.

3.5.3. Maturity of Economically Important Rattan Species in Cameroon

Small Diameter Rattans

***E. macrocarpa*:** 50% harvesters in AEZ 2 opined that that it takes 2-3 years to reach maturity; 16.7 % each mentioned that it takes < 2 years, about 4-5 years and 6-7 years respectively. In AEZ3, 40 % mentioned that *E. macrocarpa* takes 2-3 years to reach maturity; 40 %, 10% and 5% respondents mentioned that it takes 4-5 years, < 2 years and 6-7 years and above respectively to reach maturity. In AEZ 4, 95 % opined that *E. macrocarpa* takes 2-3 years and in AEZ 5, 67 % respondents opined that it takes 2 -3 years, and 23 % opined that it takes 4-5 years to reach maturity. Therefore, most respondents were of the opinion that *E. macrocarpa* takes 2-3 years in all AEZs to mature.

***C. deerratus*:** 50% harvesters in AEZ 2 mentioned that it takes 2-3 years for this rattan species to reach maturity; 16.7 % respondents opined that it takes < 2 years, 4-5 years and 6-7 years respectively. In AEZ 5, 67 % were for 2 -3 years, 23% opined that it takes 4-5 years to reach maturity. Therefore, more respondents were of the opinion that *E. macrocarpa* takes 2-3 years in all AEZs to mature.

***E. wendlandiana*:** In AEZ 4, it takes 2-3 years for this species to reach maturity; 16.7 % respondents opined that it takes < 2 years, 4-5 years and 6-7 years to reach maturity.

This study results are different from the findings of Muralidharan et al. (2020) that, small-diameter rattans, such as *C. rotang*, will reach maturity in about 6-7 years. Razali (1992) reports on the age of maturity of certain species of the genus *Calamus* thus: *Calamus trachycoleus* takes 7-10 years to reach maturity in Kalimantan; 10 years in East Kalimantan and 7 years in an undefined location. *Calamus tetradactylus* takes 6 years to reach maturity in China. *Calamus caesuis* takes 6-8 years to maturity in Indonesia, 10 years in East Kalimantan and 3 years in Kalimantan. Feaw's (1992) conservative model assumes that each stem of *C. caesuis* is harvestable at the age of 8 years and that of *Calamus trachycoleus* is harvestable at the age of

7 years. In this study, 2-3 years is reported in Cameroon as harvesters' perception, which is far different from previous studies. Harvesters' perception on age of rattan maturity at this level may have been influenced by scarcity which has caused harvesters to resort to harvesting rattan that has not attain it full maturity in Cameroon, and the situation makes them to believe that, this age range 2-3 years is the mature age for the rattan canes. Rattan age of rotation might also have confused harvester's notion of maturity age for rattan.

Large Diameter Rattan

For large diameter rattan such as *L. secundiflorum* and *L. robustum* species got similar response on age of maturity in the different AEZs. Harvesters in AEZ 3 opined that it takes 2-3 years; In AEZ 4, it takes 2-3 years and in AEZ 5 it takes same 2-3 years (Table 7). The difference in AEZs seems to have no great influence on the age to which rattan reach maturity. The results show similar age range for which this rattan species reach maturity in the different AEZs of their habitats. Muralidharan et al. (2020) after reviewing detail literature on rattan and report that large-diameter rattans, such as *C. thwaitesii* and *C. hookerianus*, take about 10–12 years to reach maturity or harvesting age. Supardi and Aminuddin (1992) reports that the suggested timing for harvesting *C. manan* is 12-15 years. There is a wide gap between the harvesters' perception on the age to which rattans take to reach maturity. High demands, scarcity and long distance trekked to harvest rattan most have make harvesters to resort to harvesting unmaturred rattan for sale. This frequent practice might have normalised the practice and make them feel, rattan at 2-3 years is matured enough for harvesting.

Table 7: Number of years it takes for *L. secundiflorum* and *L. robustum* rattan species to reach maturity

Agro-ecological zones	Time (years)	Frequency	Percent
Agro-ecological zone 3	2 - 3	10	50.0
	4 - 5	7	35.0
	6 - 7	2	10.0
	> 7	1	5.0
	Total	20	100.0
Agro-ecological zone 4	2 - 3	19	100.0
Agro-ecological zone 5	< 2	1	1.4
	2 - 3	47	65.3
	4 - 5	21	29.2
	6 - 7	3	4.2
	Total	72	100.0

3.5.4. Annual Growth Rates of Rattan in Cameroon

Small Diameter Rattan Species

The harvesters opined that *E. macrocarpa* in AEZ 2 grows about 1-2 m (66.7 %) and 3-4 m (33.3 %). In AEZ 3, the respondents opined that growth is about 1-2 m (50 %); < 1 m (30 %); 3-4 m (15 %) and 5-6 m (5 %). The growth of rattan poles is about 5-6 m (26.3 %); < 1m (26.3 %); 3-4 m (30.6 %) and 1-2 m (15.8 %) in AEZ4. In AEZ5; it is > 6 m (56.9 %); 1-2 m (22.2 %), < 1 m (12.5 %) and 3-4 m (5.6 %) and 5-6 m (2.6 %).

The majority of harvesters in AEZ2 and 3 opined that 1-2 m/year is the growth rate for *E. macrocarpa*. Sunderland et al. (2008) report that growth rates of the multi-stemmed small-diameter cane, *E. macrocarpa* is favourite when compared to similar species, *C. caesiuis* of South East Asia with annual growth rates of 3.2m and between 2.9-5.6m respectively. The result of Sunderland et al. (2008) surpasses the perception of the harvesters two times. Therefore, the observation of the 33.3% harvesters who opined for 3-4m/year, corroborates with the findings of Sunderland et al. (2008).

Considering the empirical findings of Sunderland (2012) that show the morphological length of *E. macrocarpa* to be averagely 50–75 m at maturity. Also, considering the conclusion of Muralidharan et al. (2020) that the age to which small diameter rattan attain maturity is 6-7 years. Assuming that both authors findings are correct, that is the age and growth length at maturity for *E. macrocarpa*, and the growth rate for *E. macrocarpa* can be extrapolated as $(50-75/6-7)$ 8.3-12.5m/year / 7.1-10.7m/year. This estimate of growth rate quadrupled the harvesters' perception on *E. macrocarpa*.

In Cameroon, an annual growth in length of about 3.2 m has been demonstrated for *E. macrocarpa*² *E. wendlandiana*: was found only in AEZ 4, the annual growth rate of 5-6 m (26.3 %); < 1m (26.3 %); 3-4 m (30.6 %) and 1-2 m (15.8 %). At least the perception of harvesters (26.3 %) on 5-6 m are acceptable for the growth rates, assuming that this species grows up to 60m at maturity.

C. deerratus, it grows 1-2 m (50 %); < 1 m (30 %); 3-4 m (15 %) and 5-6 m (5 %) in AEZ 2 and In AEZ 5, it grows 3-4 m (60 %) in length per year. This species from Sunderland (2021) findings grows up to 20 m at maturity. Considering that this species takes 6-8 years to mature, therefore the perception of the harvesters with 3-4 m/year (15%) may be correct for 6 years.

Triangulating literature and the findings of this study, small diameter rattan can grow 3-4 m long per year in AEZs 2 and 3; while in AEZ4, it can grow 5-6m and in AEZ 5, it can go above 6 m per year. This means that the growth rates of rattan are slow in the AEZs 2 and 3 maybe due to the climatic conditions predominated with a transitional equatorial to tropical Sudano-Guinean types. Rattan growth rates are two

²[https://uses.plantnet-project.org/fr/Eremospatha_macrocarpa_\(PROTA\)](https://uses.plantnet-project.org/fr/Eremospatha_macrocarpa_(PROTA))

to three times rapid in AEZ 4 and 5 than in 2 and 3. The AEZs 4 and 5 have a predominance of Classical Guinean Equatorial, Guinean Equatorial to Tropical Humid Types.

Different authors have reported findings on annual growth rates on similar species elsewhere. Razali (1992) records the growth rates of *C. caesius* and *C. trachycoleus* in managed holding to be 3 m/year and in unmanaged holding to be 2 m/year in Indonesia. Razali (1992) summarises other studies in different study areas thus: the growth rates of *C. caesius* in East Kalimantan is 4 m/year and that of *C. trachycoleus* in Sabah is 3 m/year, in East Kalimantan is 5 m/year, in Central Kalimantan is 4 m/year. Feaw's model (1992) of conservation assumes that *C. caesius* cane growth rate is 2.5 m/year giving a total stem length of 20 m after 8 years. The growth rate of *C. trachycoleus* is assume to be 3.5 m/year giving a total stem length of 24.5 m after 7 years.

Large Diameter Rattan

The harvesters opined that *L. secundiflorum* and *L. robustum* have an annual growth rate of 1-2m (75 %) and 3-4m (25 %) in AEZ3; 1-2 m (57.9 %); < 1 m (10.5 %); 3-4 m (15.8 %) and 5-6 m (15.8 %) in AEZ4 and in AEZ5; it was > 6 m (56.9 %); 1-2 m (29 %), and 3-4 m (15.3 %).

For *L. robustum* species; 1-2 m (58 %); < 1 m (10.5 %); 3-4 m (15.8 %) and 5-6 m (15.8 %) in AEZ4 and in AEZ5; it was > 6 (57 %); 1-2 m (29 %), and 3-4 m (15 %). Harvesters acquire that the two species play the same role, are found almost in the habits, even in market demand and they do not see why they should very much distinguish them in growth.

The majority of harvesters in AEZ3, 4 and 5 opined that 1-2 m/year is the growth rate for *L. secundiflorum* and *L. robustum*. This result is in discordance with the findings of Sunderland et al. (2008) who record that annual extension growth for the multiple-stemmed large diameter cane, *L. secundiflorum*, is 2.8m under obsolete rubber. According to his findings, this species is very rapid in growth rate compared to the *C. manan*, a single-stemmed large diameter fast growing cane from South East Asia with an annual growth rate of 1.2m under the same conditions. The fact that *L. secundiflorum* is a multi-stemmed species suggests that yields per hectare would be potentially high. The growth rate of 2.8 m is recorded for *L. secundiflorum* and *L. robustum*³. This is true for both species because the growth length at maturity for both species are within the same range 25-50m and 30-45 respectively.

From empirical findings, Sunderland (2012) shows the morphological length of *L. secundiflorum* to be averagely 25-50 m at maturity. Also, Muralidharan et al. (2020) find the age to which large diameter rattan attain maturity to be 10-12 years. Assuming the results of these two authors right, for growth length and

³[https://uses.plantnet-project.org/fr/Laccosperma_secundiflorum_\(PROTA\)](https://uses.plantnet-project.org/fr/Laccosperma_secundiflorum_(PROTA))

age at maturity for *L. Secundiflorum*, and then extrapolate the growth rate for *L. Secundiflorum* to be (25-50/10-12) 2.5-5 m/year- 2.1-4.2 m/year. This estimates growth rate quadrupled the harvesters' perception. Supardi and Aminuddin (1992) investigate and report that *C. manan* grows about 80 cm for the first 3 years, 1 m from the 4th year onward and can reach 5-7m/year when palm reaches the canopy. Growth of 1-3m/year is observed in adequate light conditions and in rubber plantations. Supardi and Aminuddin (1992)'s results confirm that the growth rate of rattan is not constant, but dynamic. It starts up slowly in the early 1-3 years, and doubles, triples or quadruples in it later developmental stage. An average growth length of 9.98m in an 8.2-year rattan plantation was recorded at Dengkil, Solangor (FAO, 2004).

Therefore, large diameter (*L. secundiflorum* and *L. robustum*) in AEZs 3 can grow 1-2 m per year while the growth rate can triple in AEZ4 and 5 to above 6 m in length per year. The results show that rattan growth rate is faster in the Coastal region of Classical Guinean Equatorial to Guinean Equatorial climates than the Guinean Equatorial to Tropical Humid types of climate in the other zones in Cameroon.

Comparing the perception of harvesters on growth potentials of rattan species in the different AEZs, the statistical test shows that, a significant variation exists in perception across the different agro-ecological zones for all the variables ($p < 0.05$) except for the number of years it takes for rattan to get to maturity ($p > 0.05$) (Table 8).

Table 8: Perception of harvesters on growth pattern of rattan species in the different AEZs

Test statistics	Number of years it takes for rattan to get to maturity	Which species of rattan grows faster	How fast does small diameter rattan grow per year	How fast does large diameter rattan grow per year	How long does it take for small diameter rattan to get to maturity	How long does it take for large diameter rattan to get to maturity
Chi-Square	5.533	14.303	24.414	33.440	18.046	17.367
df	3	3	3	3	3	3
Asymp. Sig.	.137	.003	.000	.000	.000	.001

a. Kruskal Wallis Test, b. Grouping Variable: Agro-ecological zones

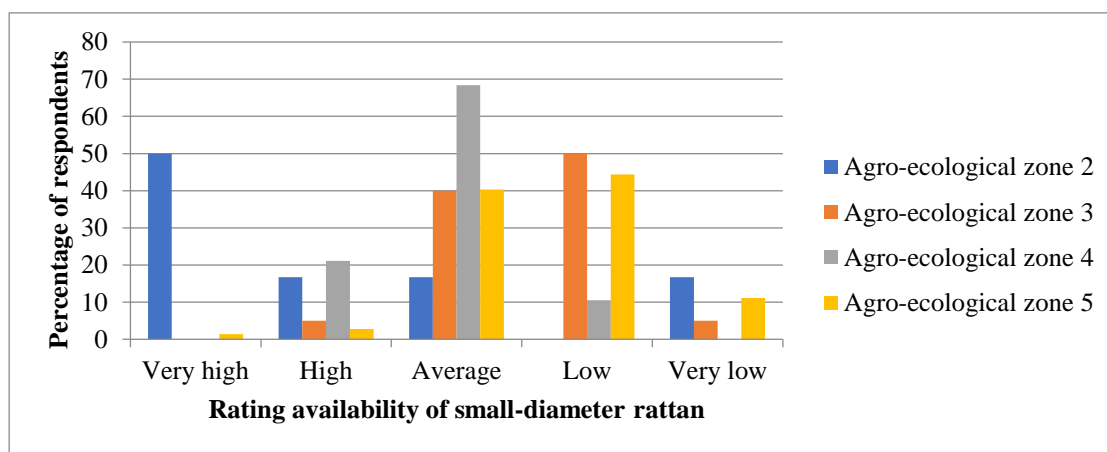
3.5.5. Availability of Rattan in the Wild

Generally, rattan was collected in the wild, since harvesters do not cultivate this natural resource. The perception of stocks of rattan available in the wild is presented in Table 9. In AEZ 2, half of the harvesters were of the opinion that rattan yields are still very high in their natural forest. Harvesters in AEZ 3, mentioned that the stocks were low. In AEZ4, the stocks were still at average level and in AEZ5, the stock are high. The very high availability of rattan in AEZ2 may be explained by the fact that, they do not have rattan markets or buyers for the resource. They use the resource mostly for domestic needs. The remaining AEZs have ready markets and the demand is high. This also increase pressure on the resource in the wild.

Table 9: Overall availability of rattan species growing in the wild

Agro-ecological zones		Frequency	Percent
Agro-ecological zone 2	Very high	3	50.0
	High	1	16.7
	Average	1	16.7
	Very low	1	16.7
	Total	6	100.0
Agro-ecological zone 3	Very high	1	5.0
	Average	8	40.0
	Low	9	45.0
	Very low	2	10.0
	Total	20	100.0
Agro-ecological zone 4	High	7	36.8
	Average	12	63.2
	Total	19	100.0
Agro-ecological zone 5	High	26	36.1
	Average	20	27.8
	Low	21	29.2
	Very low	5	6.9
	Total	72	100.0

Availability of small-diameter rattan growing in the wild: Considering available of *E. macrocarpa*, and *C. deerratus*, harvesters' opinion is represented in Figure 4. *E. macrocarpa* availability are still very high in AEZ2, low in AEZ3 and 5 and average in AEZ4.

Figure 4: available of *E. macrocarpa*

C. deerratus yields are still high in AEZ 2, since is not highly commercialized. In AEZ 5, it is moderately available.

E. wendlandiana was found in AEZ 4, and the availability are very low.

Availability of large diameter rattan growing in the wild: Harvesters perception on the availability on the *L. secundiflorum* and *L. robustum* (large diameter rattan species) are presented in figure 5. Harvesters think that large diameter rattan species availability are average in AEZ3, 4, and 5.

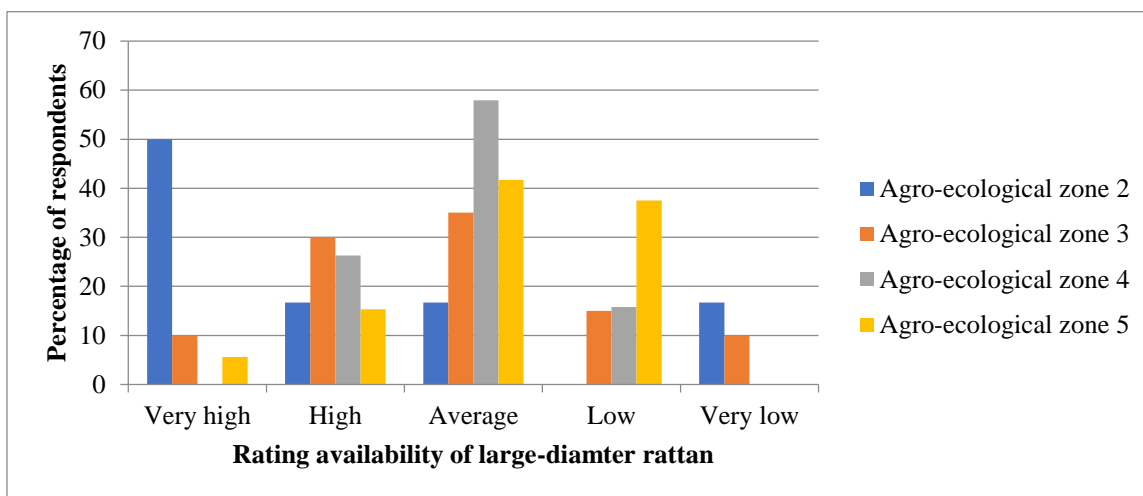


Figure 5: Availability of large-diameter rattan

Comparing perception of rattan species availability in the different AEZs in Cameroon, Chi square test shows that, a significant variation exists in perception across the different agro-ecological zones for all the variables ($p < 0.05$) except for availability of large-diameter species growing in the wild ($p > 0.05$) (Table 10).

Table 8: Harvester’s perception of rattan species availability in the different AEZs in Cameroon

Test Statistics ^{a,b}	Overall availability of rattan growing in the wild	Availability of small diameter rattan species growing in the wild	Availability of large diameter rattan species growing in the wild
Chi-Square	13.720	19.475	6.283
df	3	3	3
Asymp. Sig.	.003	.000	.099

a. Kruskal Wallis Test; b. Grouping Variable: Agro-ecological zones

3.6. Site Suitability for Expansion

Site suitable for rattan expansion depends on some biophysical conditions appropriate to the species development. These biophysical environment or characteristics include: soils, soil moisture content, climatic requirement, sunlight, canopy, nutrients levels, rattan and animals and symbiotic fungal effects. These characteristics are needed in appropriate supply as required by the rattan species.

Considering site suitability for rattan expansion in Cameroon, the different economically important species were found naturally in the AEZs of the best adaptability. Therefore, they shall do well if cultivated in the same zones.

E. macrocarpa can be cultivated in all the four AEZs of the study and can be extended in the Sudano sahel (AEZ1) after trials. *E. macrocarpa* is present at the edge of forests, in gaps and regrowth vegetation. It is extremely light demanding and reacts well to selective logging in the forest. The species is rare in swampy forests and extreme light demanding. It strives well in a wide range of soils derived from Hydromorphic, ferralitic and volcanic soils. It occurs on a wide elevation from 0-2000m.a.s.l. with a large range of rainfall 1500 -11 000 mm, with temperature range of 21-28 °C. The vegetation commonly encountered in is tropical forest; forest gap vegetation and forest margins. Other members of the genus *Eremospatha* responds extremely well to selective logging activities and is a common component of regrowth vegetation (Sunderland, 2012).

C. deerratus can be expanded in AEZ2 and 5. *C. deerratus* has a strong preference for swampy forests and riparian areas, light demanding and less common in areas with high rainfall. It is therefore relatively rare in the Guinean-Congolese forest of Cameroon. It is more common in drier gallery forests in areas of transition to the Sudanian wooded savannah in the north where rainfall ranges from 1500-1800 mm and temperature range of 23 – 25. *C. deerratus* is strictly find in the transition wooded savannah covering the northern part of East Cameroon (AEZ5) and the southern part of the Adamawa region (AEZ2) in Cameroon. *C. deerratus* mostly occurs in elevations up to 500 m above sea level. Strives well in hydromorphic and ferralitic soils. Vegetation commonly encountered is the forest, under canopy, but also occurs in open areas where it often forms dense thickets.

While *E. wendlandiana* was best discovered in AEZ4, especially on the coastal low lands of Cameroon. This species is light demanding but can support shade under canopy, Ochre red Ferralitic, hydromorphic, tauromorphic, orthotics, sandy-clay, lateritic, volcanic, andosol, vertisol soils. It is common in areas with high rainfall ranging from 2000-11000 mm, with temperature of 28°C, and elevation of 0-500 m.a.s.l. It is therefore relatively rare in the Guinean-Congolese forest of Cameroon. It is common in gap vegetation and forest margins. Sunderland (2012) records that *E. wendlandiana* is a common component of gap vegetation and forest margins, although it is commonly present in the juvenile form in closed-canopy forest where it occurs. It is commonly in coastal forest, although with outliers present in the swamp forests of the Cameroon.

L. secundiflorum and *L. robustum* were found and well adapted in AEZs 3, 4 and 5. These zones are suitable for these species' expansion in Cameroon. These rattan species are very closely similar in habitat range and are present up to 1050 m.a.s.l. in high forests, rarely in secondary forests. They are particularly abundant in seasonally flooded and swampy areas. They grow well on poorly drained, water-saturated soils in areas where the average annual rainfall is below 1600 mm (AEZ3). However, in areas where the average annual

rainfall is above 1750 mm (AEZ4 and 5), they prefer well-drained sites. These species prefer gaps in dense forest stands, and takes advantage of disturbed forest. The rhizome is easily killed by fire and will not regenerate in areas that have been burnt several times in the past. They thrive well in granitic, alluvia, hydromorphic and ferralitic soils, temperatures range of 21 – 28°C. Sunderland (2012) report that these species are commonly encountered in forest gaps and regrowth vegetation and responds well to selective-logging activities. They are encountered on both tropical moist forest and seasonally-inundated forest.

These economically important species with respect to site suitability could be expanded in their different AEZs of adaptability. Table 11 shows the key biophysical characteristics necessary for proper growth and development of each rattan species studied.

Table 11: Biophysical characteristics suitable for the expansion of economically important species in Cameroon

Rattan species	AEZs	Light availability	Soil type	Elevation (m.a.s.l)	Soil moisture	Climate requirement		Vegetation
						Temperature (°C)	Rainfall (mm)	
<i>E. macrocarpa</i>	2, 3, 4 & 5	extreme light demanding	Hydromorphic, ferralitic,	0-2000	Wet forest	21 - 28	1500-11 000	Tropical forest; Forest gap vegetation and forest margins
<i>C. deerratus</i>	2 & 5	light demanding	hydromorphic and ferralitic soils	< 500	Strong preference for swamp	23 - 25	1500-1800	Forest, under a canopy, but also occurs in open areas where it often forms dense thickets
<i>E. wendlandiana</i>	4	Light demanding but can support shade under canopy	Ochre red Ferralitic, hydromorphic, tauromorphic, orthotics, sandy-clay, lateritic, volcanic, andosol, vertisol.	0-500	wet soil	28	2000–11000	Common in gap vegetation and forest margins
<i>L. secundiflorum</i>	3,4 & 5	light demanding	Granitic, alluvia, hydromorphic and ferralitic soils	1050	Rain forests, moist forest	21 - 28	1600 and >1750	Rain forest, under forest canopy
<i>L. robustum</i>	3, 4 & 5	light demanding	Granitic, alluvia, hydromorphic and ferralitic soils	1050	Moist tropical forest and seasonally-inundated forest	21 - 28	1600 and >1750	Rain forests, Forest gaps and regrowth vegetation and responds well to selective-logging activities,

Throughout their natural range, rattan species are found in a wide range of forest and soil types (FAO,2002). Some species are common components of the forest understorey, whilst some rely on good light penetration for their development; hence several species are found in gap vegetation and respond very well to canopy manipulation, particularly that caused by selective logging. Other species grow in swamps and seasonally inundated forest whilst others are more common on dry ridge tops (Sunderland, 2012).

Despite this wide range of ecological conditions, the majority of rattans need adequate light for their development (FAO, 2002; FAO, 2004; Sunderland, 2012). Cultivation trials on germination of the African taxa, have indicated that seeds will germinate under a wide range of light conditions. The resultant seedlings will remain for long periods on the forest floor awaiting sufficient light for them to develop, such as a tree fall. This seedling bank is a common feature of the regeneration of most species and is a well-recognised component of forests where rattans occur (Sunderland et al. 2008).

3.7. Management and Harvesting Options

Rattan in Cameroon is unmanaged. Harvesters in all the communities visited for this survey make very little efforts to ensure sustainability out of rattan natural regeneration cycles. The resource increase depends on natural regeneration in the wild. Harvesters search rattan and harvest from their natural stands.

Rarity of long-term *in situ* rattan management has been reported but experimental studies in Southeast Asia, have revealed four production systems of rattan exploitation:

- Management by natural regeneration in high forest requires the development and implementation of management plans based on sound inventory data and an understanding of the population dynamics of the species concerned;
- Enhancing natural regeneration, through enrichment planting and canopy manipulation in natural forest is especially appropriate where forest has been selectively logged. The management inputs are fairly high, when there is clearance of competing undergrowth vegetation and subsequent selective felling to create "artificial" gaps with some success for the rattan resource;
- Rattan cultivation as part of shifting cultivation or in formal agroforestry systems, is the incorporation of rattan into traditional swidden fallow systems and this has been practiced in some areas of Southeast Asia;
- Silvicultural trials' concentration is on incorporation of rattan into tree-based plantation-type systems. The framework for rattan growth imperative and rattan association with tree cash crops is a long practice.

3.7.1. *Harvesting Zones and Seasons for harvesting of Economically Important Rattan Species in Cameroon*

It resulted that < 5 % of rattan harvesters during this survey obtain rattan in places other than the wild in Cameroon. Harvesters have not planted rattan in farms or home garden. Areas where harvesting often take place were in natural forests, fallows or swidden, from disturbed forested areas (logged areas), and community forests. There has been no particular season for harvesting rattan, but it was much preferred in the dry seasons when roads are accessible; and swamps where some of these rattan species are collected are easy to access. This finding corroborates with those of many authors (Sunderland, 1999; Sunderland, 2012; FAO, 2005; Gonmadje et al., 2018).

3.7.2. *Legal Frameworks for Harvesting Rattan in Cameroon*

State laws regulating the harvest of rattan in the communities: This survey tested the level the state involved in the management of the rattan in Cameroon. Their existence in the value chain is represented in Figure 6. All harvesters recognised State regulation of rattan activities in their communities or forests or on road junction.

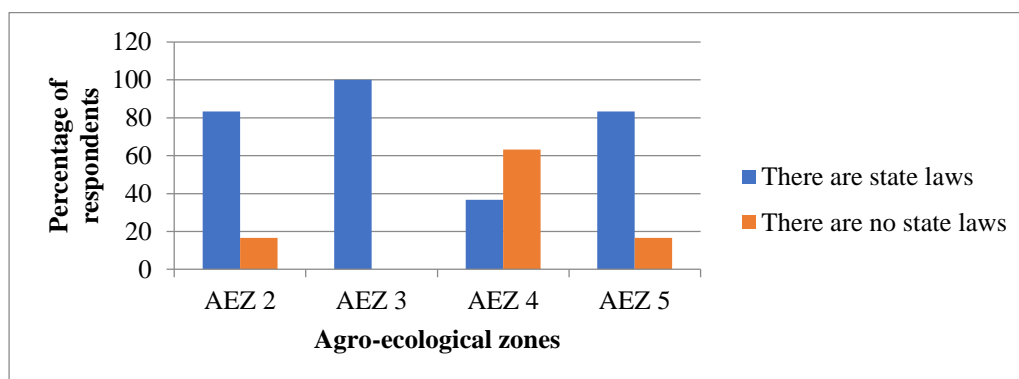


Figure 6: State laws regulating the harvest of rattan in the AEZs

State laws regulating the harvest of rattan: The Figure 7 shows the effectiveness of implementation of state laws. Harvesters were sort to know if they are aware that, the resource (rattan) they harvest is subject to State control and if enforcement agents (Foresters) do control the exploitation and sale of the rattan resource. It was very effective in AEZ2, because the forest agents allow them to exercise their user right on the resource freely. The State laws were not effective at all in AEZs 3, 4 and 5. Harvesters said Forest agents charged and collected USD 125 (70, 000 F. CFA) per camion of rattan from the forest without any backup receipt. It therefore means that, the amount does not reach the national treasury. This amount is not charged with respect to rattan species, or number of bundles loaded, but in so far as the rattan fills a truck (Camion).

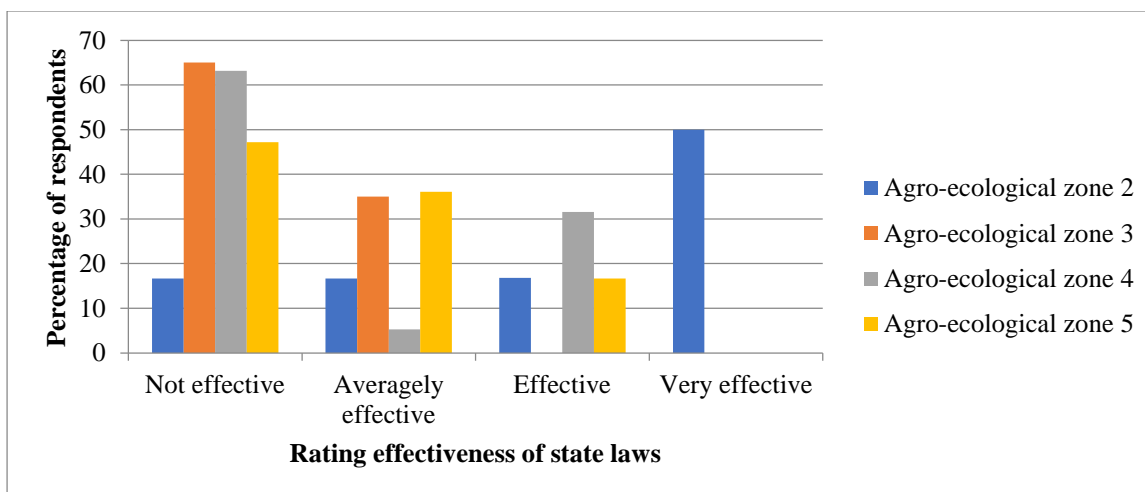


Figure 7: Effectiveness of state laws in regulating the harvest of rattan

From these results, it is evident that rattan is not managed in Cameroon despite the existing law and texts for rattan management. Law N°. 94/01 of 20 January 1994) which lay down Forestry, Wildlife and Fishery regulations in Cameroon in section 9 (2) and (3) authorised classification of special forest products by the competent Ministry. Decree N° 95/531/PM of 23 August 1995 fixing the modalities for the application of the Forest Regime in article 5(1) authorises MINFOF to fix a list of special products. MINFOF on decision No. 0209/D/MINFOF/CAB of 26 April 2019; classifies special forest products and Non-Timber Forest Products (NTFPs) and amongst NTFPs is rattan. MINFOF further on decision N° 0034/D/MINFOF/CAB of 05 February 2020, lay down conditions for transportation of NTFPs from plantations⁴. “Promoters of planted Non-Timber Forest Products shall certify ownership thereof. They shall, to this end, address a stamped (at the official rate) application for site inspection to the relative Chief of Forestry Control Post, who shall draw up a report thereof.” These regulations have to still be implemented in the field or there are twisted and implemented otherwise for personal gains (author’s pers. observ.). These justifies why the State laws are not effective in the field. In Mbalmayo. harvesters of rattan complained of the absence of transparency in the process. They even approached the officials of MINFOF to know the legal procedure of harvesting and transportation of rattan to the market, but had no fruitful information on the amount to be paid and documents to compile (informant’s pers. Observ.).

Traditional rules regulating the harvest of rattan: Harvesters’ views on the traditional or community regulation on the rattan resource was sorted out during this survey (Figure 8). The result showed that all the communities where rattan is exploited have local rules that regulated rattan harvesting. This is strongly felt

⁴ DECISION No. 0034 /D/ MINFOF/CAB OF 05 Feb. 2020. To lay down conditions for transportation of Non-Timber Forest Products from plantations

in AEZ3 where all harvesters are aware of the local regulations. This might be because the resource scarcity is higher in this zone than the other zones and so measures are in place to control the resource.

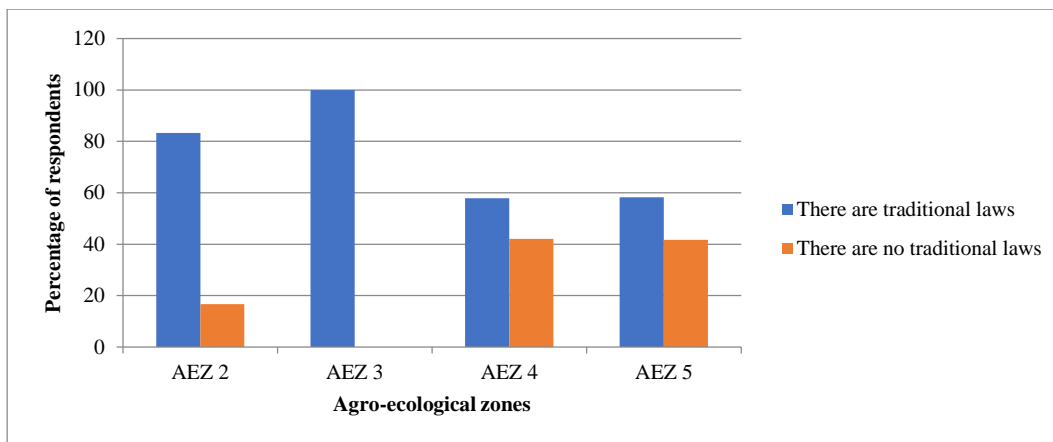


Figure 8: Traditional laws regulating the harvest of rattan

Traditional laws ensuring the sustainable harvesting of rattan: The result of the effectiveness of these regulations are presented in Figure 9. This result showed that, the regulations were very effective in AEZ2, less effective in AEZ3 and not effective in AEZ4 and 5. Regulating harvesting in AEZ 2, the villagers watch over their rattan resources from being

harvested by harvesters from neighbouring village. Within their villages, people harvest in their concessions or go very far in the wild for harvest. In AEZ4, harvesters coming from elsewhere pay USD 89.3 (50,000 F. CFA) to the chief or to the community prior to being given access in to their bush. The communities here watch over their resources and control access from non-community members.

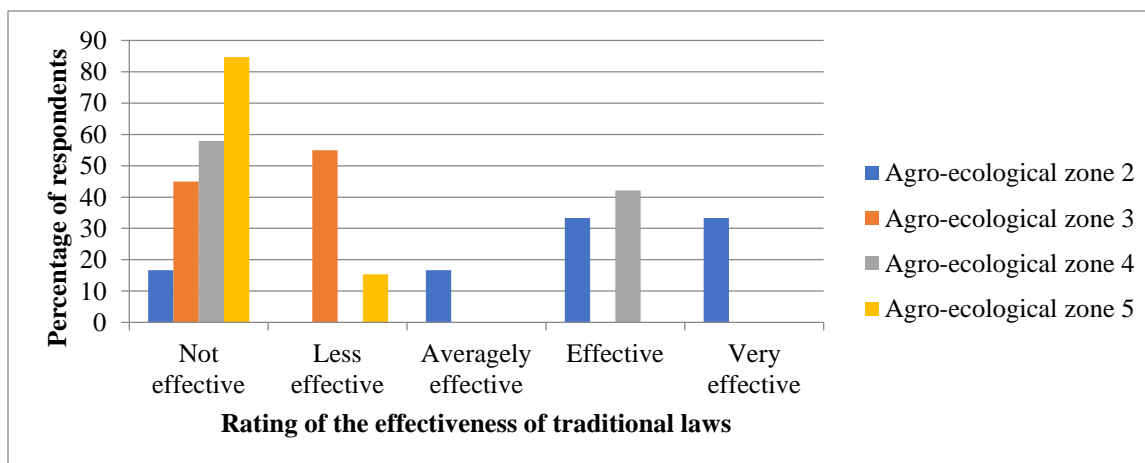


Figure 9: Effectiveness of traditional laws in regulating rattan harvest

3.7.3. *Planting of rattan on farms*

Harvesters were asked whether they have planted rattan on farms. Responses are presented in Figure 10. Less than 5 % of respondents in AEZ5 were of the opinion that they have planted rattan in Cameroon.

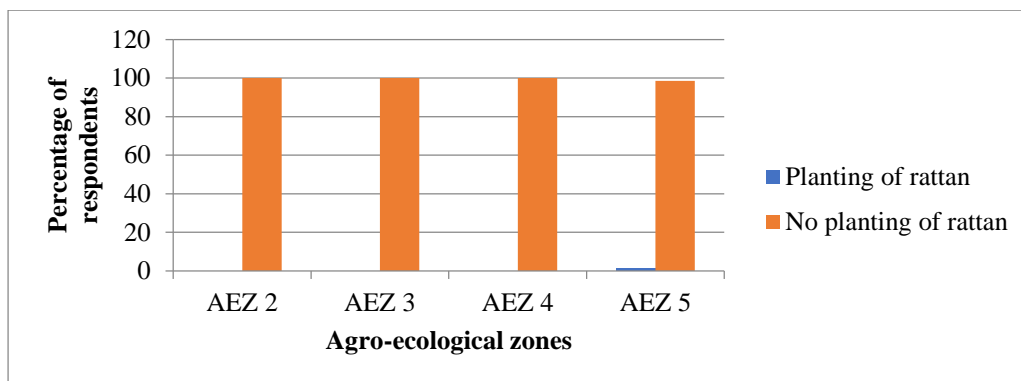


Figure 10: Planting of rattan on farms

3.7.4. *Ensuring the sustainability of rattan in the wild*

Harvesters views on how they can ensure sustainability of rattan in the wild is presented on Figure 11. Harvesters in AEZ2 have the opinion that more rattan should be planted on farms, harvesters in AEZ3 said, rattan should be harvested in a more sustainable manner. In AEZ4 and AEZ5, harvesters said nothing should be done because rattan is always available in the wild (100 %; 42 %).

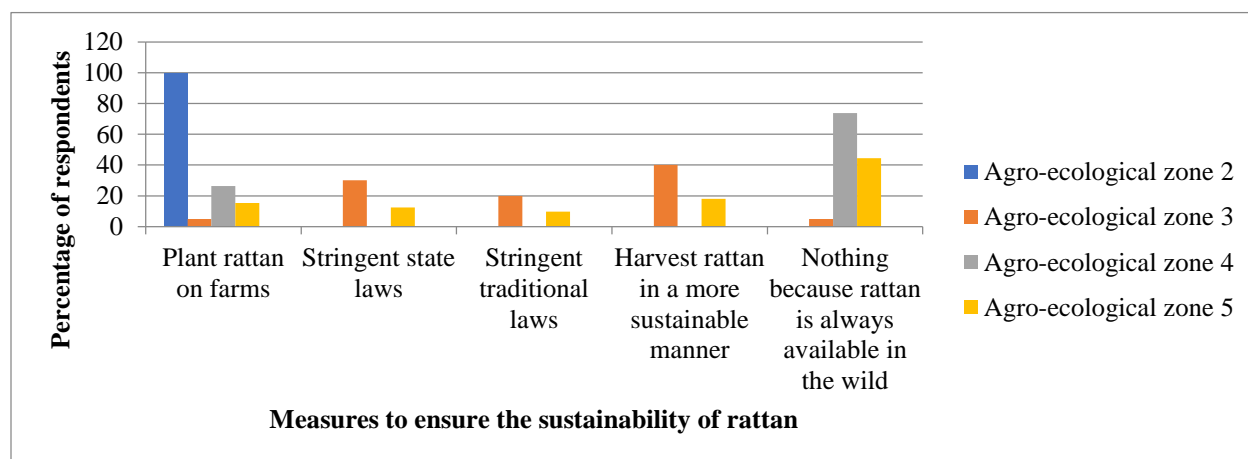


Figure 11: Sustainability of rattan in the wild

3.7.5. *Willingness to plant rattan on farms to ensure sustainability*

Harvesters’ opinion on the willingness to ensure sustainability is presented in Figure 12. Willingness to plant rattan was high in AEZ2 (100) AEZ3, (75 %), and AEZ5 (63 %). Harvesters in only AEZ4 (80 %), had no willingness to plant rattan.

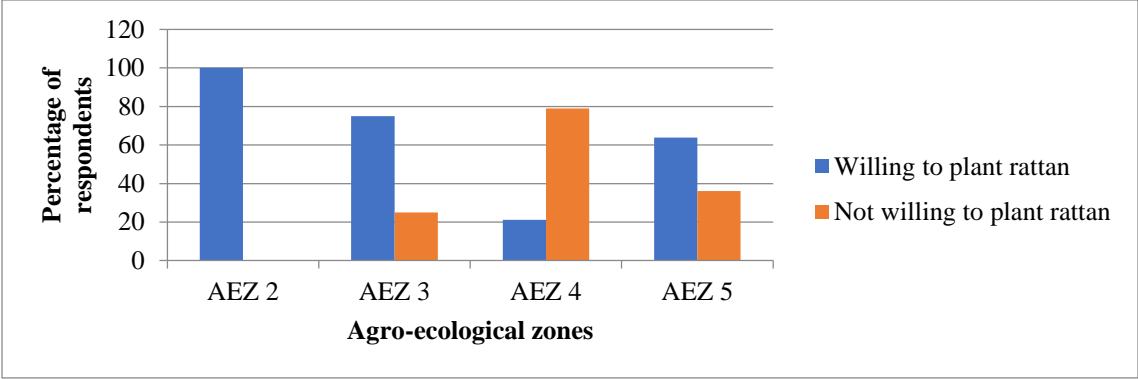


Figure 12: Willingness to plant rattan on farms

3.7.6. Propagation methods

Figure 13 below shows the opinion of harvesters on different propagation method. Seeds were the most preferred method (80%) for rattan propagation in all the AEZs. Transplanting and stem cuttings (20%) of the rattan was the second propagation methods proposed.

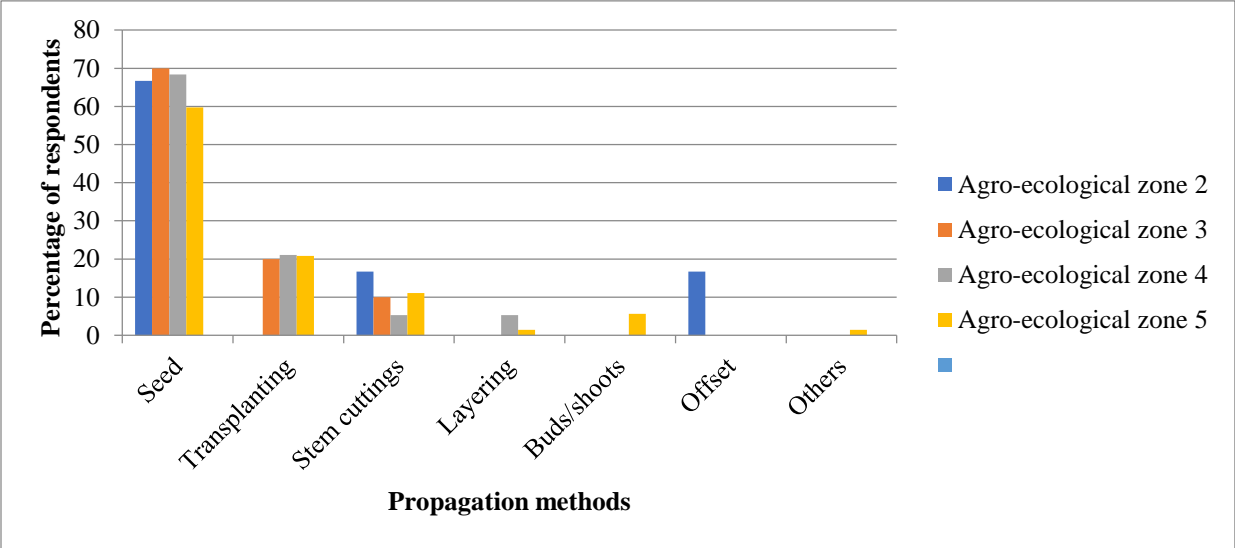


Figure 13: Propagation methods

Comparing harvesters’ perception on management of rattan species in Cameroon, the Chi square test shows that, harvesters have a significant level of knowledge on traditional and State regulations on the rattan cane harvesting and sale ($P < .05$). On sustainable measures that will increase the raw rattan in the different AEZs, harvesters are knowledgeable of what should be done ($p < .05$). Harvesters have never tried planting rattan, or thinks that without seeds, they could use other propagations methods to plant rattan (Table 12).

Table 9: harvester’s perception on management of rattan species in Cameroon

Test Statistics	Traditional laws regulating the harvest of rattan in the community	Effectiveness of traditional laws in ensuring sustainable harvesting of rattan	State laws regulating the harvest of rattan in the community	Effectiveness of State laws in ensuring sustainable harvesting of rattan	Have you been planting rattan	What do you think can be done to ensure the sustainability of rattan in the wild	Are you willing to plant rattan on your farms to ensure sustainability	Propagation methods
Chi Square	24.383	29.086	25.986	10.578	.625	19.201	18.266	1.585
df	3	3	3	3	3	3	3	3
Asymn. Sig.	.000	.000	.000	.014	.891	.000	.000	.663

3.8. Sustainable Harvesting Methods

Harvesting of rattan is very strenuous as work involves coming into contact with rattan spines, pulling the stems down from the forest canopy, hauling down death tree branch and being in contact with animals or insects’ nests (Supardi, 1992, FAO, 2004).

Important factors to consider when operating harvesting in the forest are: distance from major means of transportation system, forest structure, selection of mature stems, age of harvesting that depends on the species, and wastage in harvesting rattan which is highly dependent to: stem entangled into the canopy, collection of immature stems, lack of appropriate processing in short period of time. Average percentage in wastage can reach 12.6 - 28.5 % of the total quantity.

3.8.1. Assessing rattan availability in the wild

Rattan availability in the wild was assessed during this survey. Harvesters’ response is presented in Figure 14. Harvesters said rattan is very much available (80 %) in AEZ2, moderately available (45 %) in AEZ3, less available in AEZ4 (90 %) and finally still available in AEZ5.

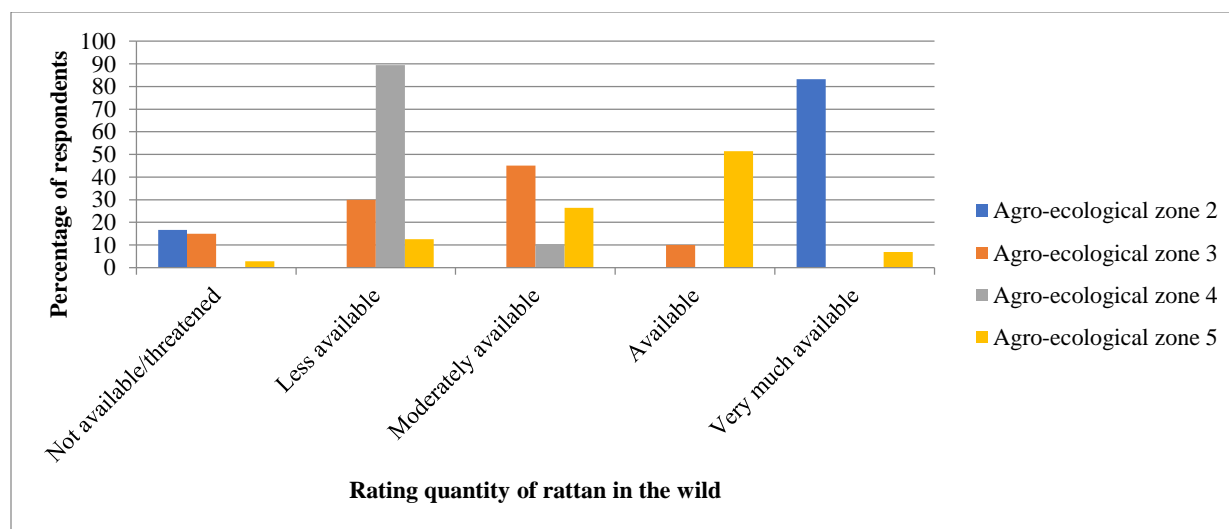


Figure 14: Quantity of rattan available in the wild

3.8.2. Source of rattan species harvested

Harvesters’ opinion on the source of rattan species harvested is presented in Figure 15. Most harvesters in the AEZs harvested rattan from the wild only. This means that rattan in Cameroon is largely exploited in the wild since the planting techniques and the necessity has not been considered as an option.

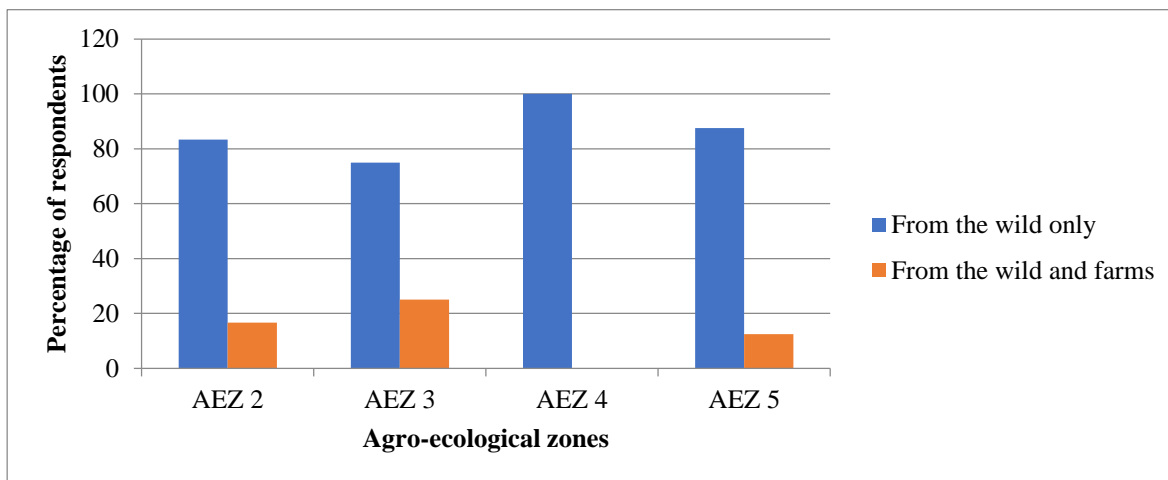


Figure 15: Source of harvested rattan species

3.8.3. Quality Most Sought When Harvesting Rattan

Figure 16 represent the parameters or quality of rattan sought by harvesters during rattan harvesting. Most harvesters in AEZ 2 based their judgement on fibre wall thickness (50 %). In AEZ 3, most considered diameter (50 %) of the rattan species, in AEZ4, they consider mostly proportion of fibrous tissue (70 %) and in AEZ5, they considered diameter and age/maturity (35 %) each.

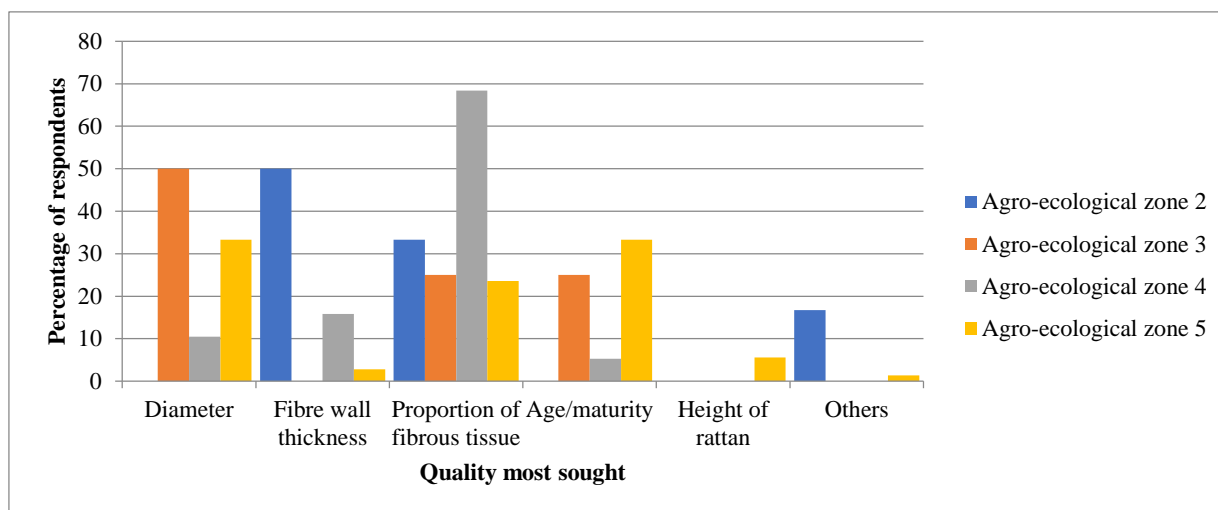


Figure 16: Quality looked for when harvesting rattan

3.8.4. Criteria for Maturity Used Most When Harvesting Rattan

The harvester’s response on the criteria for maturity most used when harvesting rattan is presented in Figure 17. Harvesters in AEZ2 (50 %) were of the opinion that the most used criteria for harvesting rattan was that ‘leaves and leaf sheaths have already dried and peeled off. Harvesters in AEZ3 used “basal portion of stems has turned dirty-green or yellowish (40 %) and no leaves at the lower part of the stem (35 %); in AEZ4, they used “stems free of thorns” (90 %); and in AEZ5, they used “basal portion of stems has turned dirty-green or yellowish” (70 %).

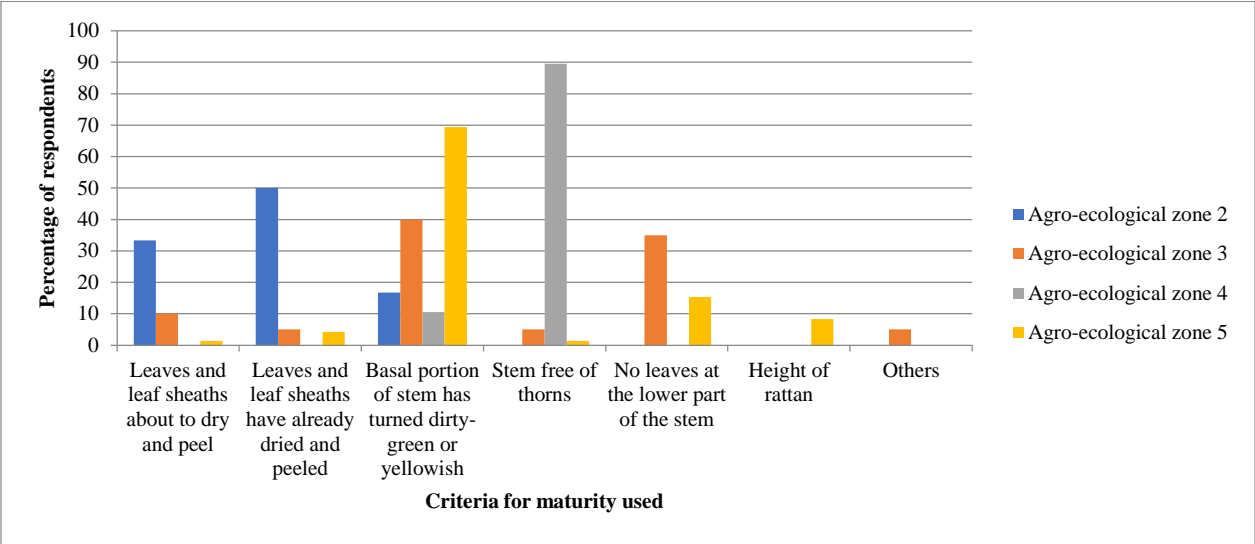


Figure 17: Criteria for maturity used most when harvesting rattan

3.8.5. Effectiveness of criteria in ensuring the harvesting of mature rattan

The harvesters’ response on the criteria for maturity most used when harvesting rattan is presented on the Figure 18. Harvesters said the criteria used in ensuring the harvesting of mature rattan were effective in AEZ2 (64 %), AEZ3 (47 %) and AEZ5 (62 %). These criteria were averagely effective in AEZ4 (100 %).

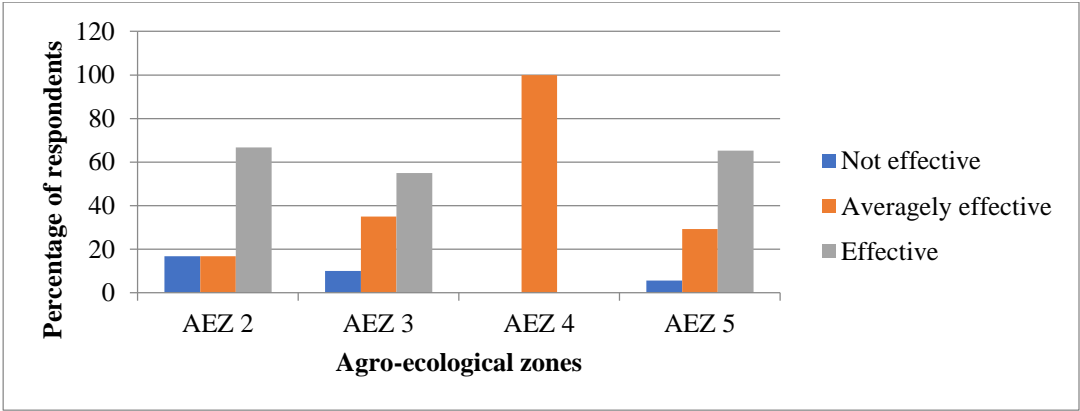


Figure 18: Effectiveness of criteria in ensuring the harvesting of mature rattan

3.8.6. Harvesting methods

Harvesters’ opinion on harvesting techniques is presented in the figure 19. They answer to whether they cut all stems in a cluster in order to get mature rattan. All in AEZ2 responded never, harvesters in AEZ3 said they cut it frequently (64 %); in AEZ4 (80 %) and AEZ5 (38 %) said they cut all stems occasionally.

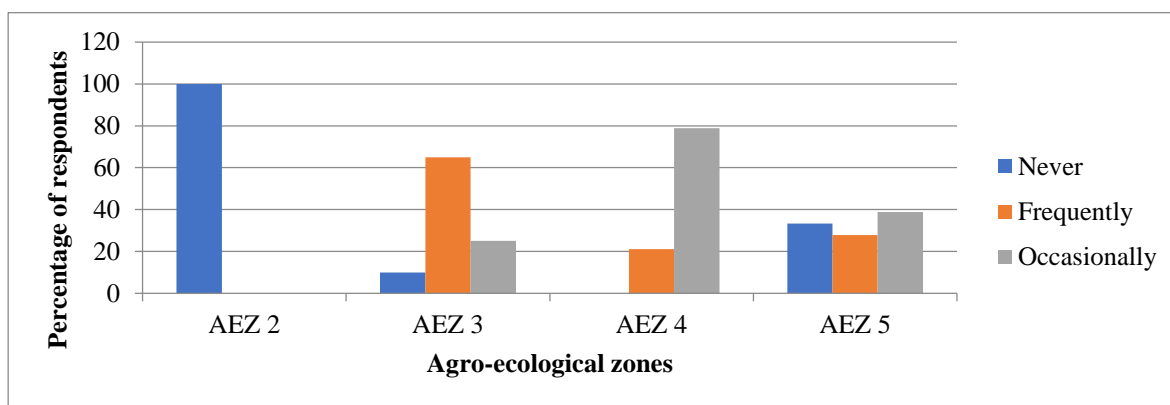


Figure 19: Cutting all stems in order to get mature rattan

Elsewhere, Muralidharan et al. (2020) report that, harvesting is carried out by local indigenous communities who were familiar with the forests and had the necessary skills. Besides the shortage of skilled labour and the inefficiency of the process, such harvesting in modern times is bound to be economically unviable. Gnanaharan and Mosteiro (1997) describe the local tools and technologies available in different countries for rattan harvesting. The use of mechanical devices has been tested by FRIM in Malaysia, but was not found to be very promising due to the time taken and the damage resulting to the rattan harvested as well as the support trees (Chong et al., 1998). No pre-treatment is carried out when rattan stems are harvested; they are dried under sunlight and stored in sheltered and lifted wood frames.

Comparing sustainable harvesting yields and methods, the chi square show that, a significant variation exists in perception across the different agro-ecological zones for all the variables ($p < 0.05$) except for source of rattan species and the quality of rattan most sought out ($p > 0.05$) (Table 13).

Table 10: Sustainable harvesting and methods in Cameroon

Test Statistics	Overall, how do you rate the quantity of rattan available in the wild	Where have you been harvesting your rattan	Quality you seek most when harvesting rattan	Criteria for maturity used the most when harvesting rattan	Effectiveness of these criteria in ensuring the harvesting of mature rattan	How often do you cut all the stems in a cluster in order to have access to mature rattan
Chi Square	43.675	5.487	2.684	21.689	19.894	23.628
Df	3	3	3	3	3	3
Asymn. Sig.	.000	.139	.443	.000	.000	.000

3.8.7. Harvestable lengths in the different AEZs

Harvesters collected rattan in different AEZs with respect to certain lengths as seen in the table 14. The different lengths dependent to an extent, the accessibility to rattan collection zones, the distance from bush to main transport roads. Small diameter rattans were harvested and bundled (packets) of 20 canes 5 m in length. The large canes were harvested and bundled in to 10-15 canes of 3-5 m in AEZ 3, and 15- 20 in AEZ 4 and 5. There exists a unit price for each cane. Harvester receives payment per stem and depending on the quality; small diameter cost USD 0.37 (200 F. CFA) and large diameter USD 0.55 (300 FCFA). Bundle of small or large diameter is sold for USD 7.31 (4000 F CFA).

Table 114: harvestable lengths of cane with respect to the entire rattan lengths

AEZs	Rattan species	Life growth length ⁵ (m)	Harvestable length (m)	Number of canes per packet	remarks
2	<i>E. macrocarpa</i>	50–75 m and rarely to 150 m	15-20	-	do not tie in bundles
	<i>C. deerratus</i>	≤ 20 m	5-15	-	do not tie in bundles
3	<i>E. macrocarpa</i>	50–75 m and rarely to 150 m	20-25	20	sold per cane
	<i>L. secundiflorum</i>	30–45 m	10-20	10 - 15	
	<i>L. robustum</i>	25-50 m	10-15	10 – 15	
4	<i>E. macrocarpa</i>	50–75 m and rarely to 150 m	70-80	20	sold per cane
	<i>L. secundiflorum</i>	30–45 m	10-20	15 - 20	
	<i>L. robustum</i>	25-50 m	10-15	15 - 20	
	<i>E. wendlandiana</i>	≤ 60 m	35-40	20	
5	<i>E. macrocarpa</i>	50–75 m and rarely to 150 m	30-50	20	Sold per cane
	<i>L. secundiflorum</i>	30–45 m	20-25	15 - 20	
	<i>L. robustum</i>	25-50 m	20-25	15 - 20	
	<i>C.deerratus</i>	≤ 20 m	5-10	20	

3.8.8. Determinants of Willingness to Plant Rattan on Farms

The logistic regression analysis was used to show the variables determining willingness to plant rattan on farms in Cameroon (Table 15). The main determinants according to this result were household size ($p < 0.05$), availability of market for rattan ($p < 0.10$); AEZ ($P < 0.05$) and average monthly income ($P < 0.05$). However, Sunderland et al. (2008) report the difficulties hindering the expansion of rattan in Cameroon and African in particular that although the cultivation of these

⁵Sunderland T. C.H. (2012). A taxonomic revision of the rattans of Africa (Areaceae: Calamoideae) (Phytotaxa 51) 76 pp.

resources have proven economic and ecological potential, particularly in multi-strata agroforestry systems, farmer adoptability has, up until now, proven to be low due to the influence of a wide range of socio-economic factors, notably land and resource tenure issues and the reluctance of farmers to try new, untested, crops. Sunderland et al. (2008) further point out the long germination times and high mortality of rattan seeds, predation on the young emerging rattan seedling; secure and tenure is required before planting perennial crops; market competition as rattan cannot really compete with other crops like oil palm; conceptual (problem of introducing new crop they do not really understand the future). The latter study is more than one decade today, and a lot has evolved in technology and local perception on the rattan resource.

Table 15: Determinants of willingness to plant rattan on farms

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Agro ecological zone	-.387	.250	2.397	1	.122	.679
Age	-.030	.026	1.383	1	.240	.970
Average monthly income	-.388	.297	1.698	1	.193	.679
Main occupation	-.123	.182	.457	1	.499	.884
Household size	.224	.084	7.168	1	.007	1.252
Number of years spent in the community	-.009	.019	.254	1	.614	.991
Availability of market for rattan	.857	.485	3.119	1	.077	2.356
Availability of farm to market roads	.299	.483	.382	1	.536	1.348
Constant	2.653	1.385	3.672	1	.055	14.201

4. Conclusions

In Cameroon, rattan's northern limit is the South of Adamawa and it is found mainly in the Southern part of the national territory. *E. macrocarpa*: a clustered, slender to moderate palm climbing to 50–75 m and rarely to 150 m, is distributed in all the different study AEZs, followed by *L. secundiflorum*: a clustered moderate to robust palm, climbing to 25–50 m and *L. robustum*: clustered robust palm climbing to 30–45 m, in all but AEZ2; *C. deerratus*: a clustered, slender to moderate palm climbing to 20m is found in AEZs 2 and 5 and *E. wendlandiana*: a clustered moderate to robust palm climbing to 60 m, is encountered only in AEZ 4. Current conservation status of rattan shows that all were of least concern (LC) according to IUCN red list but some of them are locally threatened due to exploitation pressures. Habitat preference for *C. deerratus* is swamps and wet forests; *E. macrocarpa* is light demanding, occurring naturally in gap vegetation and forest margins; *L. secundiflorum* in high forest and commonly found under forest canopy; *L. robustum* is in gaps vegetation and regrowth vegetation, and also encounters in *terra firma* and seasonally-inundated forest; and *E. wendlandiana* is a component of gap vegetation and forest margins. Rattan harvesters 50 % (AEZ2); 40 % (AEZ3); 95 % (AEZ4) and 67 % (AEZ5) were of the opinion that the different studied rattan genera (*Eremospatha*, *Laccosperma* and *calamus*) take 2-3 years to attain maturity. As per the opinion of rattan harvesters in AEZ2 (67 %), AEZ3 (50 %) and AEZ4 (28 %) each genus: *Eremospatha*, *Laccosperma* and *calamus* possess similar annual growth rates in the different AEZs. Small diameter rattan (*Eremospatha*) witnessed the longest growing lengths per year likely > 6m. Harvesters believed that, availability were very high in AEZ2 (50 %); low in AEZ3 (45 %); average in AEZ4 (63 %) and high in AEZ5 (36 %). Site suitability for expansion required includes: soils (with laterite, red lateritic, red and yellowish red type); soil moisture (not subjected to severe dry conditions and dislike waterlogging or prolonged flooding); climate of temperature between 25 and 27 °C and annual rainfall over 2000 mm; light (40-50% Relative Light Intensity) for rattan seedlings; nutrients levels; animals' dispersal, and fungal-rattan symbiosis. All AEZs have rattan regulated by the State laws and customary rules although not effective in all the different AEZs. In some localities, traditional law also regulated rattan exploitation. More than 95 % of rattan was harvested from the wild. No cultivated source of rattan is recorded in the survey. All harvesters express the willingness to plant rattan on farms ($P < 0.05$), with main determinants being household size ($P < 0.05$) and availability of market for rattan ($P < 0.10$).

5. Recommendations

These recommendations target the objectives of this study. The following are the key recommendation to:

5.1. Growth pattern of rattan species per AEZ in Cameroon

- Trials should be carried out in rattan research plots to determine the actual growth rates of rattans, for the local or harvesters' perception on growth rates could be misleading; when compared to related literature on rattan.
- *E. macrocarpa* is a rattan species that is adapted to the four AEZs 2, 3, 4 and 5. It is recommended to be developed with respect to its habitat preference in all the AEZs. *E. wendlandiana* is adapted to AEZ 4 and so should be developed in its habitat preference within this zone. *C. deerratus* is adapted to AEZs 2 and 5. This species is recommended to be developed with respect to its habitat preference in these zones. The genus *Laccosperma* is adapted in AEZs 3, 4 and 5. Their development is recommended in these zones in so far as their habitat preference is respected.

5.2. Harvesting options and necessary measures for the sustainable management of economically important rattan in Cameroon

- INBAR and partners should develop voluntary guideline standards (VGS) for the management of rattan natural stands; rattan propagation; plantation establishment, rattan agroforestry system development, harvesting methods, etc.; VGS for rattan certification and rattan products standardisation;
- The Government of Cameroon (Ministry of Forestry and Wildlife and other law enforcement officers) should enforce decisions No. 0209/D/MINFOF/CAB of 26 April 2019; classifying special forest products and Non-Timber Forest Products (NTFPs) affecting rattan harvesting, circulation and trade in Cameroon.
- Government and development partners should increase advocacy and capacity building on sustainable rattan management (nursery, plantation, management, harvesting etc.); and improving the rattan value chain development by technology transfer and skills development, especially at the pre-processing and processing levels (transformation stage) and markets;
- Funders: World Bank, IMF, AfDB, IFAD, CGIAR, should support government initiatives in the development of rattan sector in Cameroon.
- Civil Society Organizations (CSOs) should support government in the development of the rattan strategic documents, capacity building, advocacy, sensitizations, and policy recommendations to improve the rattan industrial development.

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Appendix

Appendix 1: Questionnaire

Dear respondent, I am here for a research work which is being undertaken within the framework of a project that seeks to enhance the sustainability of rattan in the five agro-ecological zones of Cameroon. In this light, your responses will be treated with confidentiality as this research work is purely for academic purposes. I will therefore be grateful if you can help me in completing this task by responding to the questions.

A. General information

1. Name of respondent (optional)_____
2. Name of village_____
3. Respondent/household number_____
4. Date_____

B. Growth and yield of rattan

1. How long does it take for rattan in general to get to maturity? (a) <2 years (b) 2 – 3 years (c) 4 – 5 years (d) 6- 7 years and > 7 years
2. Which species of rattan grows faster? (a) small-diameter rattan (b) large diameter rattan
3. How fast does small-diameter rattan species grow per year? (a) < 1m (b) 1 – 2m (c) 3 – 4 m (d) 5 – 6 m (e) over 6 m
4. How fast does large-diameter rattan species grow per year? < 1m (b) 1 – 2m (c) 3 – 4 m (d) 5 – 6 m (e) over 6 m
5. How long does it take small-diameter rattan to get to maturity? (a) < 2m (b) 2 – 3m (c) 4 –5 m (d) 6 – 7 m (e) over 7 m
6. How long does it take large-diameter rattan to get to maturity? (a) < 2m (b) 2 – 3m (c) 4 –5 m (d) 6 – 7 m (e) over 7 m
7. How will you rate the overall yield of all the rattan species growing in the wild? (a) very high (b) high (c) average (d) low (e) very low
8. How will you rate the yield of small-diameter rattan species growing in the wild? (a) very high (b) high (c) average (d) low (e) very low
9. How will you rate the yield of large-diameter rattan species growing in the wild? a) very high (b) high (c) average (d) low (e) very low

C. Harvesting of rattan

1. How frequently do you harvest rattan from the wild? (a) very frequently (b) frequently (c) occasionally (d) rarely (e) very rarely (f) never

2. Which rattan species do you frequently harvest? (a) small-diameter rattan (b) large-diameter rattan

3. What accounts for your choice in (2) above? _____

4. Which quality do you seek most when harvesting rattan? (a) diameter (b) fibre wall thickness (c) proportion of fibrous tissue (d) age/maturity

5. Which criteria of maturity do you use the most when harvesting rattan? (a) leaves and leaf sheaths about to dry and peel (b) leaves and leaf sheaths have already dried and peeled (c) basal portion of stem has turned dirty-green or yellowish (d) stem free of thorns (e) no leaves at the lower part of the stem

6. How effective are these criteria in ensuring that only mature rattan is harvested? (a) very effective (b) effective (c) averagely effective (d) less effective (e) not effective

7. Are there any traditional laws regulating the harvest of rattan in your community? (a) Yes (b) No

8. If Yes, how effective are these traditional laws in ensuring the sustainable harvesting of rattan in your community? (a) very effective (b) effective (c) averagely effective (d) less effective (e) not effective

9. Are there any state laws regulating the harvest of rattan in your community? (a) Yes (b) No

10. If Yes, how effective are these state laws in ensuring the sustainable harvesting of rattan in your community? (a) very effective (b) effective (c) averagely effective (d) less effective (e) not effective

D. Sustainability of rattan

1. How is the demand for rattan and cane products in your area? (a) very high (b) high (c) average (d) low (e) very low

2. Which are the most common rattan species and cane products traded in your community?

3. Where have you been harvesting your rattan from? (a) from the wild only (b) from the wild and farms (c) from the farm only

4. How often do you cut all the stems in a cluster (including young stems not yet mature enough for exploitation and sale) in order to obtain access to mature stems? (a) very frequently (b) frequently (c) occasionally (d) rarely (e) very rarely (f) never

5. Over all, how do you rate the quantity of rattan available in the wild? (a) very much available (b) available (c) moderately available (d) less available (e) not available/threatened

6. How will you rate the quantity of large-diameter rattan available in the wild? (a) very much available (b) available (c) moderately available (d) less available (e) not available/threatened

7. How will you rate the quantity of small-diameter rattan available in the wild? (a) very much available (b) available (c) moderately available (d) less available (e) not available/threatened
8. Have you been planting rattan on your farms? (a) Yes (b) No
9. If Yes, since when have you been planting rattan on your farms? (a) < 3 years ago (b) 3 – 5 years ago (c) 6 – 8 years ago (d) 9 – 11 years ago (e) over 11 years ago
10. Are you willing to plant rattan on your farms? (a) Yes (b) No
11. If Yes, how willing are you? (a) very much willing (b) willing (c) moderately willing (d) less willing
12. What do you think can be done to ensure that the rattan in the wild does not get exhausted? _____

Appendix 2: Guide for the identification of studies rattan species in Cameroon

Sunderland T. C.H. (2012). A taxonomic revision of the rattans of Africa (Arecaceae: Calamoideae) (Phytotaxa 51) 76 pp.



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