Ethnobotanical Uses of Non-cultivated Edible Fruit Species in the Department of Oussouye (South Senegal)

Yves Djihounouck[1], Doudou Diop[2], César Bassene[3], Seyni Sane[1] & Kandioura Noba[1]

[1] Botany and Biodiversity Laboratory, Department of Plant Biology, Cheikh Anta Diop University of Dakar, BP 5005, Senegal

[2] Botany Laboratory, Institut fondamentale d'Afrique Noire (IFAN), Cheikh Anta Diop University of Dakar, BP 206, Senegal

[3] Section of Plant Production and Agronomy, Faculty of Agronomic Sciences, Aquaculture and Food Technologies, Gaston Berger University of Saint Louis, BP 234, Senegal

Correspondence: Yves Djihounouck, Botany and Biodiversity Laboratory, Department of Plant Biology, Cheikh Anta Diop University of Dakar, BP 5005, Senegal. Tel: 221-772-096-605. E-mail: djihounouck01@yahoo.fr

Abstract

Forests are an immense reservoir of biological resources and provide the local population with subsistence needs, especially for edible fruits. This study contributes to a better knowledge of the use modes of non-cultivate edible plant species in the area of *Kasa,* traditional name for the department of Oussouye. Ethnobotanical surveys, based on an interview guide, oral discussions and direct observations were conducted among 178 people from the department of Oussouye, stronghold of the *Diola* ethnic group. A factorial correspondence analysis highlighted the relationship between species and categories of use. The frequency of citation, informant consensus factor and use value showed the socio-cultural importance of the species. The data collected identified 62 edible species divided into 31 families and 54 genera. The fruit species inventoried are used for different purposes. They are a food source with 62% of citations, energetic 19%, technological 14%, medicinal 13%, cultural 6% and agronomic 2% for the populations. Two species stand out for their high use value factor (UVt). These were *Elaeis guineensis* (12.24) and *Borassus aethiopum* (7.56). In addition to their use value, species such as *Mangifera indica*, *Neocarya macrophylla*, *Parkia biglobosa*, *Anacardium occidentale, Ceiba pentandra*, *Parinari excelsa*, stood out for their categories and organs used. These results inform us about the level of use of fruit species for different needs and open up avenues for research in sustainable management of this resource with the aim of reducing poverty.

Keywords: plant species, Diola, added value, potential uses, *Kasa*

1. Introduction

Tropical forests constitute an immense reservoir of biological resources for pharmacopoeia, food, construction, timber industry and handicrafts among local populations. Thus, they provide local populations with subsistence needs. In rural areas, people's lives depend on non-timber and timber forest products (Bikoué & Essomba, 2007).

For a long time, the place occupied by non-timber forest products (NTFPs) and timber products in development policies has been minimal and often limited to indigenous uses. However, the contribution of these products to food security and primary health care has been amply demonstrated, as nearly 80% of the population in developing countries use them for health care or food (Allabi *et al*., 2011). In this sense, traditional medicine relieves more than 70% of the populations of the Third World (Malaisse, 1992) and 80% of the African peoples (Jiofack *et al.* , 2009). Thus, traditional medicine has become part of the culture of African populations although it still remains informal (Sofowara, 1982). In Senegal, 550 plants are considered medicinal and toxic in the pharmacopoeia (Kerharo & Adam, 1974). However, the use of plants requires a wider and deeper knowledge in order to be able to integrate them into the socio-economic development processes of the populations.

In Africa, non-cultivate plants are used daily by the great majority of peasant peoples (Grivetti *et al*., 1987). These plants essentially contribute to the food and survival of rural people by providing scarce nutrients in their diet (Ayessou *et al*., 2011). In Senegal, the species most used by the populations have been determined by

ethnobotanical methods based on inventories and uses of species in domains such as food and medicine (Diop, 2011; Dieng, 2017; Djihounouck *et al*, 2018). However, this assessment does not cover the department of Oussouye even though fragmentary data on the uses of a limited number of species in this locality happened to be collected. Data collection on the uses of plant species is an important step in supporting decentralized programs for the conservation and development of forest resources (Ayessou *et al*., 2009; 2011; Diop *et al*., 2010), hence the need to conduct this study among the populations in the department of Oussouye in order to contribute to better management of these natural resources. This study contributes to the knowledge of the uses of edible fruit species in the *Kasa* area. To this end, the specific objectives of the study are to:

~   identify the different categories of uses of the inventoried wild edible species;

~   describe their uses to optimize the contribution of forest genetic resources to sustainable socio-economic development;

2. Methodology

The department of Oussouye is located in southwestern Senegal and covers 891 km ²i. e. 12.14% of the area of the Ziguinchor region. It is bordered to the east by the Kamobeul marigot, the north by the Casamance River, the west by the Atlantic Ocean and Cape Roxo, and the south by Guinea Bissau. It includes five communes that total seventy-five (75) villages, with a population of 48.331 inhabitants in 2013 (ANSD, 2015). **(Figure 1)**
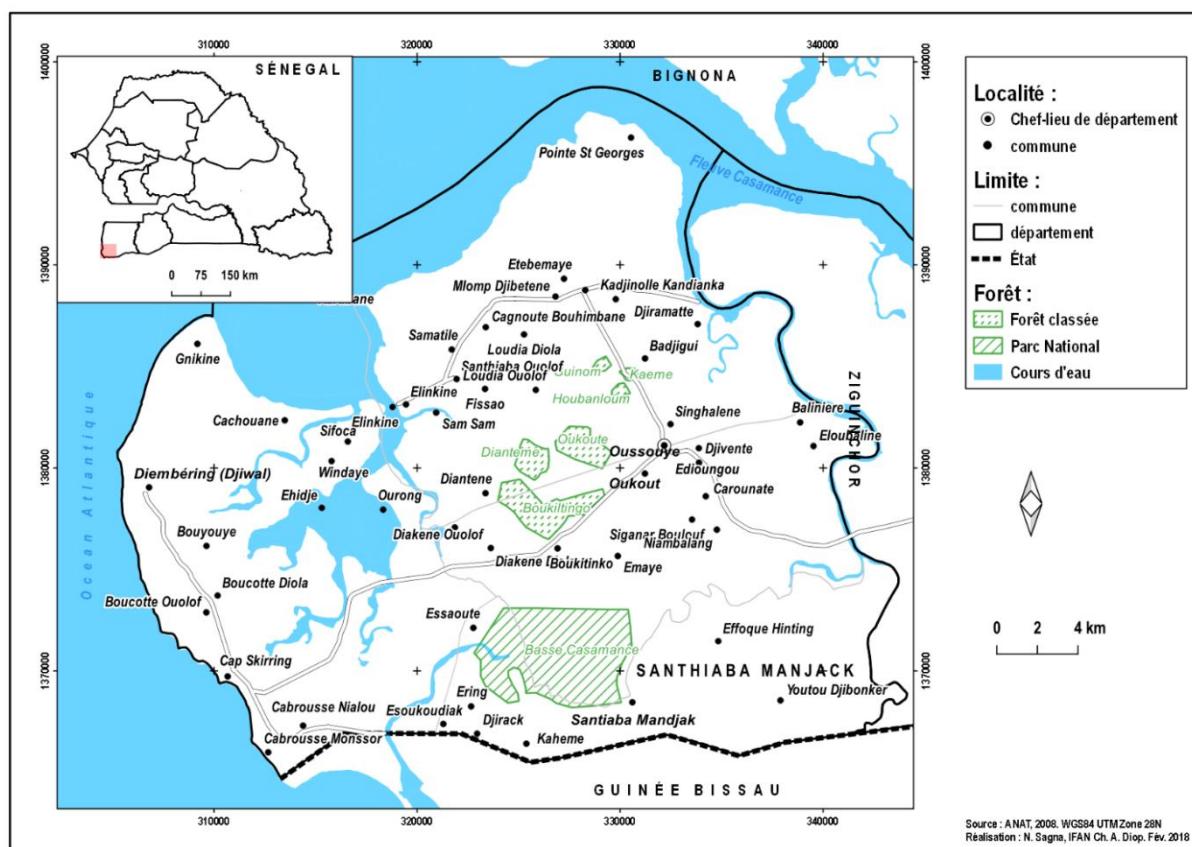
Figure 1. Map of the administrative division, hydrographic network and forest areas of the Oussouye department (*Source: ANAT, 2008. WGS84 UTM Zone 28N. Production: N. Sagna Ifan Ch. A. Diop Feb. 2018).*

The study population is made up of the Diola who are the majority ethnic group in the department of Oussouye. The language spoken by this ethnic group bears the same name (*Diola*) and is made up of several dialects. When the dialect is not mastered during the ethnobotanical survey, we call in an interpreter to ensure good communication. A first interview was conducted with randomly selected people in villages. This contact visit allowed us to get an idea of how the species studied contribute to the life of the population and select the areas of activity. The choice of the villages where the surveys should be conducted was made taking into account the local forest resources that allow harvesting activities. The newly created villages called batogat were not chosen because they do not have cultural originality due to the loss of ancestral values. Villages affected by the

Casamance conflict were excluded from the survey. Based on those criteria, 34 villages were selected for data collection. These villages are located in five (5) traditional communities (*An Alufay, Esulalu, Ejamat, Dyiwat and Her or Haer*). Each community is distinguished from the others in its dialect, organization and social practices. The choice of interviewees was non-probabilistic and their identification was done for convenience. Their selection by study area and village depended on their availability. They were chosen with the help of the village Chiefs, targeting individuals whose activity, experience or status was related to the topic. They were herders, gatherers, traditional family caterers, and farmers. The interviews were carried out between 2012 and 2014 mainly with indigenous adults, with a preference for men who have a better knowledge of non-cultivate species and who have experience in their mode of use. The choice of these people was made in order to reduce the risk of uncertain or vague answers. Data were collected through semi-structured interviews and casual conversations.

Semi-structured interviews were conducted using an interview guide which included the following headings: interviewee identification, form of use, socio-cultural importance of the species, and description of use modes. Casual conversations were used to estimate responses and gather new information (Martin, 1995).

The local name of each plant studied was transcribed into local language based on specialized documents (Adam, 1970; Berhaut, 1967) or by using the Diola alphabet codified with reference to the local language of the *An Alufaye* community.

The identification of fruit plants was done either on site or in the botany laboratory of IFAN and the botany and biodiversity laboratory of the Department of Plant Biology (BV) using the various flora of Senegal by Berhaut (1979; 1976; 1975a; 1975b; 1974; 1971; 1967) and Van Der Berghen (1988), and the works of Hawthorne and Jongkind (2006), Arbonnier, (2002) and Hutchinson and Dalziel (1954), Wieschus (2000) and the herbarium collections of Dakar and IFAN. The nomenclature adopted is that of the database of the Conservatoire et Jardin Botanique (C.J.B) of the city of Geneva, which is regularly updated (Lebrun & Stork, 1997; 1995; 1992; 1991).

Qualitative data were processed using the content analysis method (Faucault, 1966; Négura, 2006). This process consists of a systematic and methodical examination of textual and / or visual documents. Applied to qualitative data, it captures the contextual dimension of these documents and highlight the categorical determinants.

Quantitative data were processed according to descriptive statistics using response rate (Van den Eyden *et al.*, 1994; Cotton, 1996).

The data obtained were analyzed with Epi Info software and the results were processed by Excel spreadsheet which allowed us to establish cross-tabulations [species /organs], [species/use], [species/method of collection], [species/stage of development] and the R software (Core Team, 2017) with the factoextra package (Version: 1.0.5), for Factorial Correspondence Analysis (FCA) allowing to study the relationships between different species and categories of use. A test of independence of Chi2 with a threshold of significance of 5% was previously carried out in order to verify the independence between the different species and the categories of use. The information collected was analyzed on the basis of ethnobotanical indicators.

➢   **Frequency of Citation (FC)** is used to determine the level of use of different species in a category and ranges from 0 to 100. The value 0 indicates that the species is not used in this category and 100 when the species is used in this category by all interviewees. It is expressed by the following formula:

FC= (S/N) 100% where:

- S : number of citations of a species in a category;

- N : total number of informants.

➢   **Informant Consensus Factor (ICF)** measures the variability of species use forms (Trotter & Logan, 1986). Always between 0 and 1, the value of this ICF is high when only one or a small number of species are cited by a large proportion of informants for a specific use category. Conversely, the greater the diversity of species cited for the same use, the closer the value will be to 0. The ICF is calculated from the following formula:

ICF = Nur - Nt / (Nur - 1) where,

- Nur (user-reports number) is the number of uses indicated in a given category;

- Nt (number of taxa) the number of species involved in this same use category.

➢   **Use Value (UV$_{(K)}$)** is a way of expressing the importance of each family or species for the population intervieweed. It significantly identifies the species with a high use value in a given environment (Dossou *et al* .,

2012). It was calculated according to the method used by Philips & Gentry (1993) and Camou-Guerrero and his team (2008) using the following formula:

$$UV_{(K)} = \frac{\sum_i^n si}{n} \text{ where,}$$

- **UV** $_{(k)}$ is the ethnobotanical use value of species k within a given use category,

- **si** is the number of uses assigned by respondent i within this category,

- **n** is the number of respondents for a given category of use.

The total use value (**UV$_t$**) of species k is then calculated by summing the use values of that species within the different use categories by the formula:

$$UV_t = \sum_1^p UV \text{ where,}$$

- **UV$_t$** represents the total use value of the species,

- **UV** is the use value of the species for a given use category, p is the number of use categories.

3. Results

Thirty-four (34) villages were visited as part of this survey. The number of interviewees varied from 38 to 4 per area and 2 to 6 in each village. In total, eighty-two (82) informants were interviewed individually or in groups. This amounts to identifying one hundred and seventy-eight (178) interviewees in the five traditional areas.

3.1 Use Values

Data collected made it possible to inventory 62 non-cultivate edible fruit plant species distributed in 31 families. *Apocynaceae* and *Annonaceae* are the most represented with 6 species each. They are followed by *Anacardiaceae* (5 species) and *Chrysobalanaceae, Arecaceae* and *Rubiaceae* (4 species each). The other families are made up of *Sapindaceae, Caesalpiniaceae, Moraceae, Celastraceae* (3 species each), *Bombacaceae* and *Zingiberaceae* (2 species). The remaining 19 families are each represented by 1 species. (**Table 1**)

Generic diversity is also important with 54 genera in total. The family *Anacardiaceae* is the most diverse with 5 genera, followed by *Annonaceae, Arecaceae* and *Rubiaceae* with 4 genera each, *Apocynaceae, Chrysobalanaceae, Sapindaceae, Celastraceae, Caesalpiniaceae* with 3 genera and *Moraceae, Bombacaceae* with 2 genera each. The remaining families are represented by only one genus each. (**Table 1**)

These species are grouped in 6 use categories which are food, medicinal, technological, agronomic, energetic and cultural. The organs used are 7 in total, namely fruit, wood, leaf, root, bark, exudate and flower. (**Table 1**)

The analysis of the results shows:

- ▪ 6 use categories concerning 3 species: *Elaeis guineensis*, *Neocarya macrophylla* and *Parinari excelsa*;

- ▪ 5 use categories represented by 8 species;

- ▪ 4 use categories for 17 species;

- ▪ 3 use categories for 9 species;

- ▪ 2 use categories for 15 species;

- ▪ and 1 use category for 10 species.

Regarding the organs harvested, the results indicate:

- ▪ 6 organs used in *Elaeis guineensis*, *Mangifera indica* and *Cola cordifolia* ;

- ▪ 5 organs exploited in 15 species;

- ▪ 4 organs in 15 species;

- ▪ 3 organs in 6 species;

- ▪ 2 organs in 13 species;

- ▪ and 1 organ in 10 species.

The use values are:

- ▪ high in two palm trees: *Elaeis guineensis* with 12.24 and *Borassus aethiopum* with 7.56;

- ▪   medium [3.87-2.35] in *Neocarya macrophylla* , *Mangifera indica* , *Parkia biglobosa* , *anacardium occidentale* , *Ceiba pentandra* , *Parinari excelsa* , *Dialium guineense* and *Adansonia digitata* .

- ▪   low to very low for the rest of the species.

These species are useful to the population in several fields: food, medicine, technology, agronomy, energy and culture. The organs used are fruits, wood, leaves, bark, roots, flowers and exudate.

The food use of the species is the most frequent, followed by the medicinal use. Our results show that there is not a close proportionality between the use value of the species and its organs used. A species can be highly prized for one organ in a given environment, while another species with multiple uses is poorly known (**Table 1**). For example, *Borassus aethiopum* (UVt = 7.56) with five use categories and four organs used, is highly used while *Parinari excelsa* (UVt = 2.59) with six use categories and five organs exploited, is very little sought after.

Table 1. Categories, organs used and use value of species

Families	Scientific name	Local Name	Use categories	Organs used	Use value (UV$_t$)
Arecaceae	*Elaeis guineensis* Jacq.	ka bekel, ka hiit	Fo, Med, Tech, Ag, En, Cul	Fr, Wo, Le, Ro, Ex, Fl	12.24
Arecaceae	*Borassus aethiopum* (L.) Mart.	ka lahaay	Al, Med, Tech, En, Cul	Fr, Wo, Le, Ro, Fl	7.56
Chrysobal anaceae	*Neocarya macrophylla* (Sabine) Prance	bu bita, bu ŋafay, beel	Fo, Med, Tech, Ag, En, Cul	Fr, Wo, Le, Ba, Ro	3.87
Anacardia ceae	*Mangifera indica* L. "Perse"	bu mangali bu jóoluay, bu mangu bu jóoluay	Fo, Med, Tech, Ag, En	Fr, Wo, Le, Ba, Ro, Fl	3.76
Mimosacea e	*Parkia biglobosa* (Jaq.) Benth.	bu nalay, bu n íók	Fo, Med, Tech, Ag, En	Fr, Wo, Le, Ba, Ro	3.7
Anacardia ceae	*Anacardium occidentale* L.	bu talakasa, bu bisa	Fo, Med, Tech, Ag, En	Fr, Wo, Le, Ba, Ro	3.5
Bombacac eae	*Ceiba pentandra* (L.) Gaertn	bu sana	Fo, Med, Tech, Ag, En	Fr, Wo, Le, Ba, Ro	3.23
Chrysobal anaceae	*Parinari excelsa* Sabine	bu wel, bu fujay, e liik	Fo, Med, Tech, Ag, En, Cul	Fr, Wo, Le, Ba, Ro	2.59
Caesalpini aceae	*Dialium guineense* Willd.	bu fulan, bu foyitay	Fo, Med, Tech, En	Fr, Wo, Le, Ro	2.43
Bombacac eae	*Adansonia digitata* L.	bu koŋa, bu baak	Fo, Med, Tech, Cul	Fr, Le, Ba	2.35
Nympheac eae	*Nymphaea spp*	bu kikif, e bah ál	Fo, Tech	Fr, Le, Ro	1.99
Apocynace ae	*Landolphia dulcis* (Sabine) Pichon	bu bot, bu ñohol, bu ñohon	Fo, Med, Tech	Fr, Wo, Le, Ba, Ro	1.98
Annonacea e	*Xylopia aethiopica* (Dunal) A. Rich.	bu ḷew ba fiŋoe	Fo, Med, Tech, En	Fr, Wo, Le, Ro	1.85
Annonacea e	*Uvaria chamae* P. Beauv.	bu ḷew	Fo, Med, Tech, En	Fr, Wo, Le, Ba, Ro	1.74
Sapindace ae	*Aphania senegalensis* (Juss. Ex Poir.) Radlk.	bu uḷ	Fo, Med, Tech, En	Fr, Wo, Le, Ro	1.74
Sapindace ae	*Allophyllus africanus* P. Beauv.	bu singilit, bu huḷ a mata, bu fankahen	Fo, Med, Tech, En	Fr, Wo, Le, Ro	1.66
Apocynace ae	*Saba senegalensis* (A. DC.) Pichon	bu h ńdik, bundok	Fo, Med, Tech, En	Fr, Wo, Le, Ex	1.63
Arecaceae	*Phoenix reclinata* Jacq.	bu faba faba, bu sanjab, bu juka, bu jak	Al, Med, Tech, Ass	Fr, Wo, Le, Ro	1.62
Rubiaceae	*Sarcocephalus latifolius* (Sm.)	bunduf áy,	Al, Med, Tech,	Fr, Wo, Le,	1.6

	E.A.Bruce	buntunf áy, bu kunduf áy	En	Ro	
Anacardia ceae	*Spondias mombin* L.	bu ḷeḷu, bu ḷiḷu	Fo, Med, Tech, En	Fr, Wo, Le, Ba, Ro	1.54
Rubiaceae	*Gardenia erubescens* Stapf. & Hutch.	bu kookay ba nale	Fo, Med, Tech	Fr, Wo, Le, Ba, Ro	1.51
Apocynace ae	*Landolphia heudelotii* A. DC.	bu hemb	Fo, Med, Tech	Fr, Wo, Le, Ro, Ex	1.48
Verbenace ae	*Vitex doniana* Sw.	bu jink, bu kuʄ	Fo, Med, Tech, En	Fr, Wo, Le, Ba, Ro	1.48
Anacardia ceae	*Sorindeia juglandifolia* (A. Rich.) Planch.	bu totol, bu totol e kaw, bu lalalen, bu foot, bu singilit	Fo, Med, Tech, En	Fr, Wo, Le, Ro	1.41
Avicenniac eae	*Avicennia germinans* (L.) L.	bu bej	Fo, Med, Tech, Ag, En	Fr, Wo, Le, Ro	1.4
Sterculiace ae	*Cola cordifolia* (Cav.) R. Br.	bu g ʄin, bu j ƙin	Fo, Med, Tech, Ag, En	Fr, Wo, Le, Ro, Ba, Ex	1.38
Celastrace ae	*Salacia senegalensis* (Lam.) D.C.	bu fumb, bu lá1	Fo, Med	Fr, Wo, Le, Ba, Ro	1.27
Apocynace ae	*Voacanga africana* Stapf.	bu ḷefukál, bu ḷenf e jaamen, bu hiʄan hiʄ, buntiñ, bungóḷ	Fo, Med, Tech, Cul	Fr, Wo, Le, Ex	1.26
Annonacea e	*Annona senegalensis* Pers.	bu lá1óf	Fo, Med, Tech, En	Fr, Wo, Le, Ba, Ro	1.22
Rutaceae	*Zanthoxylum zanthoxyloides* (Lam.) Zepern. & Timler	hu ŋuna, bu joginam, bu kosindal	Fo, Med, Tech, En	Fr, Wo, Le, Ba, Ro	1.2
Icacinacea e	*Icacina oliviformis* (Poir.) J. Raynal var. oliviformis	bu tima, buntima	Fo, Med, Tech	Fr, Le, Ro	1.18
Apocynace ae	*Landolphia hirsuta* (Hua) Pichon	bu gisay	Fo, Tech	Fr, Ex	1.12
Zingiberac eae	*Aframomum cereum* (Hook. f.) K. Schum.	bu humay, bu hefay	Fo, Med, Tech	Fr, Ro	1.09
Rubiaceae	*Psychotria peduncularis* (Salisb.) Styerm.	bu gílen, bu lel e haʄ	Fo, Med, Tech	Fr, Wo, Le, Ro	1.07
Rubiaceae	*Macrosphyra longistyla* (DC.) Hiern.	bu juḷ e jaamen, bu kokoḷ, bu giḷ e jaamen	Fo, Med	Fr, Wo, Le, Ro	1.02
Moraceae	*Ficus lutea* Vahl	bu fok (bu kunʄul), bu kunʄun, bu fok (bu ganʄul)	Fo, Med, Tech, Ag, En	Fr, Wo, Le, Ex	0.99
Polygalace ae	*Atroxima afzeliana* (Oliv.) Stapf.	bu miiton	Fo, Med	Fr, Le	0.91
Passiflorac eae	*Passiflora foetida* L.	mu te ñay, bu kuma kuma, bu ʄobek, bu ting, bu sik ń	Fo, Med	Fr, Wo, Fe	0,89
Meliaceae	*Azadirachta Indica* A. Juss.	bu niwakin	Fo, Med, Tech, En	Fr, Wo, Le, Ro	0,78
Capparida ceae	*Ritchiea capparoides* (Andr.) Britt.	bu naanaa a mata, bu lulumay a mata, bu saḷ a mata, e toj e heeji	Fo, Med	Fr, Wo, Le, Ro	0.72
Moraceae	*Treculia africana* Decne.	buit ók	Fo, Med, Tech	Fr, Wo, Ex	0.71

Chrysobal anaceae	*Chrysobalanus ellipticus* Sol. ex Sabine	bu ŋoñ, bu sima, bu uḷ e jakaḷ	Fo, Med, Tech, En	Fr, Wo	0.61
Cucurbitac eae	*Cucumis metuliferus* E. Mey. ex Naudin	bu konkombra e firika, bu konkombura, e giḷ e jaamen	Fo, Med	Fr, Le	0.61
Ebenaceae	*Diospyros ferrea* (Willd.) Bakh.	bu wing a ligen, lalalen	Fo, Med, En	Fr, Wo	0.35
Clusiaceae	*Mammea africana* Sabine	b áál	Fo, Med	Fr, Le	0.33
Caesalpini aceae	*Detarium senegalense* J.F. Gmel.	bu gawuj, bu bunkut ba te ñey	Fo, Med	Fr, Le	0.29
Sapindace ae	*Pancovia bijuga* Willd.	bunta ñ, bu lu ñay	Fo, Med, En	Fr, Le, Wo	0.28
Caesalpini aceae	*Tamarindus indica* L.	bu dahar	Fo, Med	Fr, Le	0.22
Apocynace ae	*Landolphia owariensis* P. Beauv.	bu tiyok, bu tik	Fo, Med	Fr, Ro	0.17
Zingiberac eae	*Aframomum elliotii* (Bak.) K. Schum.	bu humay e kobol, bu hefay e kobol	Fo	Fr	0.13
Euphorbia ceae	*Drypetes floribunda* (M üll. Arg.) Hutch.	bu huuta, bunkóḷ	Fo	Fr	0.12
Arecaceae	*Calamus deerratus* G. Mann & H. Wendl.	ka hihá, ka ḷiyá	Fo, Tech	Fr, Wo	0.12
Annonacea e	*Monanthotaxis barteri* (Baill.) Verdc.	bu ḷew ba yine	Fo	Fr	0.11
Sapotaceae	*Synsepalum brevipes* (Baker) T. D. Penn.	bundukul	Fo	Fr	0.09
Rhamnace ae	*Ziziphus mauritiana* Lam.	sidem	Fo	Fr	0.09
Annonacea e	*Uvaria thomasii* Sprag. Et Hutch.	bu ḷew bu jal	Fo, Med	Fr, Ro	0.09
Annonacea e	*Annona glauca* Schumach. & Thonn.	bu lala	Fo, Med	Fr, Ro	0.07
Ulmaceae	*Celtis toka* (Forssk.) Hepper & J.R.I. Wood	buwintol	Fo	Fr	0.06
Moraceae	*Ficus capensis* Thunb.	bu fok	Fo	Fr	0.06
Chrysobal anaceae	*Chrysobalanus orbicularis* Schumach.	nu lo ña	Fo	Fr	0.05
Zygophylla ceae	*Balanites aegyptiaca* (L.) Del.		Fo	Fr	0.02
Anacardia ceae	*Pseudospondias microcarpa* (A. Rich.) Engl.	bu nunu	Fo	Fr	0.02

Fo: food; **Med**: medicinal; **Tech**: technological; **Ag**: agronomic; **En**: energetic; **Cu**: cultural.

Fr : fruit; **Le** : leaf ; **Ba** : bark; **Wo** : wood ; **Ro** : root; **Ex** : exudate; **Fl** : flower.

3.2 Use Categories

Non-cultivate fruit species can be useful in several ways. The results on their use modes show 6 categories of use (**Table 2**). These are:

- food where all species are mentioned;

- medicinal with 52 useful species;

- technological with 39 species;

- energetic with 27 species;

- agronomic with 10 species;

▪   cultural with 9 species.

The most used species in these different categories are: *Elaeis guineensis* with 378 citations, *Borassus aethiopum* with 343 citations, *Mangifera indica* with 266 citations, *Parkia biglobosa* with 227 citations, *Ceiba pentandra* with 226 citations, *Neocarya macrophylla* with 212 citations and *Parinari excelsa* with 210 citations (**Table 2**).

The frequency of citation (**Table 2**) is greater than 50% in:

▪   38 species in the food sector;

▪   9 species in the energy sector;

▪   6 species in the technological sector;

▪   4 species in the cultural sector;

▪   1 species in the medicinal f sector and less than 50% in agronomy.

This frequency of citation of species by populations can be high, medium or low depending on the category of use. For example, *Borassus aethiopum*, *Phoenix reclinata* are highly used in cultural field whereas they are not in medicine. A low use value may be due to a lack of knowledge about the plant or the disappearance of certain species due to forest erosion.

Table 2. Frequency of citation of the different use categories of non-cultivate edible fruit species

Scientific name	Number of citation	Frequency of Citation (FC) in %					
		Fo	Med.	Tech	Ag	En	Cul
Mangifera indica	266	100	57	28	43	96	
Elaeis guineensis	378	100	49	100	65%	100	99
Landolphia dulcis	127	100	49	6			
Parkia biglobosa	227	100	44	24	18	90	
Nauclea latifolia	126	100	39	4		55%	
Adansonia digitata	163	100	38	57			3
Neocarya macrophylla	221	100	38	16	5	96	4
Anacardium occidentale	197	100	34	1	7	98	
Aphania senegalensis	141	100	34	1		37	
Uvaria chamae	134	100	28	24		55	
Saba senegalensis	112	100	26	22		1	
Salacia senegalensis	101	100	23				
Borassus aethiopum plant	143	100	21	100		98	100
Ceiba pentandra	126	100	21	80	60	9	54
Landolphia heudelotii	114	100	21	18			
Annona senegalensis	97	100	15	4			
Parinari excelsa	210	100	60	32	1	78	33
Vitex doniana Sw	115	100	10	60		18	
Aframomum cereum	90	100	9	1			
Dialium guineense	189	100	7	34		89	
Nymphaea spp	84	100	1	1			
Allophyllus africanus	137	98	6	5		59	
Phoenix reclinata	134	96	1	5			61
Xylopia aethiopica	133	94	44	21		4	
Macrosphyra longistyla	80	93	5				
Sorindeia juglandifolia	113	91	7	2		37	
Atroxima afzeliana	74	89	1				
Mombin spondias	121	88	4	52		4	
Icacina oliviformis var. oliviformis	93	87	23	4			
Cola cordifolia	104	82	22	16	1	6	
Passiflora foetida	70	80	5				
Gardenia erubescens	115	78	29	33			
Avicennia germinans	108	73	4	7		48	
Landolphia hirsuta	91	73	1	37			
Treculia africana	58	63	6	1			
Cucumis metuliferus	51	61	1				

Species	Fo	Med	Tech	Ag	En	Cul	
Ficus lutea	78	57	6	5	1	26	
Voacanga africana	100	52	2	59		1	7
Psychotria peduncularis	84	48	17	2			35
Chrysobalanus ellipticus	44	46	1	2		4	
Ritchiea capparoides	51	37	26				
Mammea africana	26	30	1				
Detarium senegalense	26	29	2				
Pancovia bijuga	23	23	4			1	
Tamarindus indica	18	21	1				
Diospyros ferrea	28	65	5			16	
Landolphia owariensis	15	65	5				
Monanthotaxis barteri	55	65					
Drypetes floribunda	60	60	1	1			
Aframomum elliotii	10	60					
Uvaria thomasii	7	7	1				
Synsepalum brevipes	6	7					
Ziziphus mauritiana	6	7					
Zanthoxylum zanthoxyloides	92	6	65	38	1	54	
Azadirachta indica, neem tree	63	6	4	6	0	61	
Celtis toka	5	6					
Ficus capensis	5	6					
Annona glauca	5	4	2				
Calamus deerratus	10	2		10			
Balanites aegyptiaca	2	2					
Chrysobalanus orbicularis	2	2					
Pseudospondias microcarpa	2	2					

Fo : food; **Med** : medicinal; **Tech** : technological; **Ag** : agronomic; **En** : energetic; **Cul** : cultural

Table 3 shows the fidelity index of the 62 species used in the six use categories. Thus, the fidelity index is greater than 50% for 47 species in the food sector and for only 1 species, namely *Calamus deerratus*, in the technological field. The rest of the species have fidelity indices below 50%.

The results of the Factorial Correspondence Analysis **(FCA)** between the use categories and the 62 harvested species are presented in **Figure 2**. The prior Chi2 independence test showed a statistically significant relationship between the use categories and the 62 species (X-squared = 4975.9, df = 305, *p-value* < 2.2e-16). These results show that the frequency of use of these categories varies according to the species exploited. **Table 3** presents the inertia of each of the factorial axes obtained after transformation of the original variables by the FCA. The percentage of inertia of each of the first 2 dimensions (axes) is higher than the average threshold $(1/5)*100 = 20\%$. The first two dimensions account for 69% of the total inertia of the original variables. Thus, all the analyses will be done in the factorial plane composed by these first two dimensions.

Table 3. Distribution of the inertia according to the dimensions (Dim)

Axes	Dim1	Dim 2	Dim 3	Dim 4	Dim 5
Proper value	**0.27**	**0.21**	0.10	0.07	0.07
Inertia	**39.12**	**29.89**	14.65	52.5%	5.83
Cumulative percentage of inertia	**39.12**	**69**	83.66	94.16	100

Figure 2 of the FCA allows us to isolate three groups (G1, G2, G3). Dimension 1, which accounts for 39.12%, opposes group 3 in the negative abscissa to groups 1 and 2 in the positive abscissa. Dimension 2 (29.89%) also opposes group 2 in the negative ordinates to group 1 in the positive ordinates.

Group 1 characterizes the species used in the technological and cultural categories. The species *Elaeis_guineensis* (3.3), *Borassus_aethiopum* (5.5), *Ceiba_pentandra* (8.1), which have a contribution above the threshold (average of the absolute contributions = 1.6), represent this group; group 2 includes species for agronomic and energy use characterized by *Parkia_biglobosa* (7.2), *Zanthoxylum_zanthoxyloides* (3.9) and group 3 of species for food and medicinal use characterized by *Salacia_senegalensis* (3.1), *Sarcocephalus_latifolius* (1.8). This study shows that the species:

Parinari excelsa, *Elaeis guineensis*, *Borassus aethiopum*, *Calamus deerratus*, *Ceiba pentandra*, *Voacanga africana*, *Psychotria peduncularis*, *Phoenix reclinata* (8 species) are more related to technological and cultural uses;

Azadirachta indica, *Zanthoxylum zanthoxyloides*, *Diospyros ferrea* , *Mangifera indica*, *Anacardium occidentale*, *Parkia biglobosa*, *Neocarya macrophylla*, *Dialium guineense*, *Avicennia germinans*, *Allophyllus africanus* (9 species) are related to agronomic and energy uses;

Atroxima afzeliana, *Aframomum cereum*, *Adansonia digitata*, *Aframomum elliotii*, *Annona glauca*, *Annona senegalensis*, *Aphania senegalensis*, *Balanites aegyptiaca*, *Cola cordifolia*, *Chrysobalanus ellipticus*, *Cucumis metuliferus*, *Chrysobalanus orbicularis*, *Dryicus topetibicularis*, *Feticus topetibicularisunda*, *Deticus topetibicularisea*, *Feticus topetibicularis*, *Fevericus senegalensi* , *Gardenia erubescens*, *Icacina oliviformis*, *Landolphia dulcis*, *Landolphia heudelotii*, *Landolphia hirsuta*, *Landolphia owariensis*, *Mammea africana*, *Monanthotaxis barteri*, *Macrosphyra longistyla*, *Nymphaea -spp*, *Pancovia bijuga*, *Passiflora foetida*, *Pseudospondias microcarpa*, *Ritchiea capparoides*, *Synsepalum brevipes*, *Sorindeia juglandifolia*, *Sarcocephalus latifolius*, *Spondias mombin*, *Saba senegalensis*, *Salacia senegalensis*, *Treculia africana*, *Tamarindus indica* , *Uvaria chamae*, *Uvaria thomasii*, *Vitex doniana*, *Xylopia aethiopica*, *Ziziphus mauritiana* (45 species) are correlated with food and medicine.

Use categories with an above-average absolute contribution (16.6) have helped build dimensions 1 and 2. Thus:

➢ The food use category (31.9) has contributed significantly to building dimension 1;

➢ The energy use category (24.1) has contributed negatively to dimension 1.

Dimension 1 opposes food and medicinal categories to energy and agronomic categories and therefore distinguishes the species used in these different categories.

➢ The cultural use category (37) has contributed positively to building dimension 2.

Analysis of the results (**Figure 2**) shows that food and medicinal species in group 3 outnumber the species in groups 1 and 2. These results also show that the nature of the subsistence needs of the *Kasa* populations is mainly food and medicinal. These results also reveal categories that are highly correlated with each other and with the species.
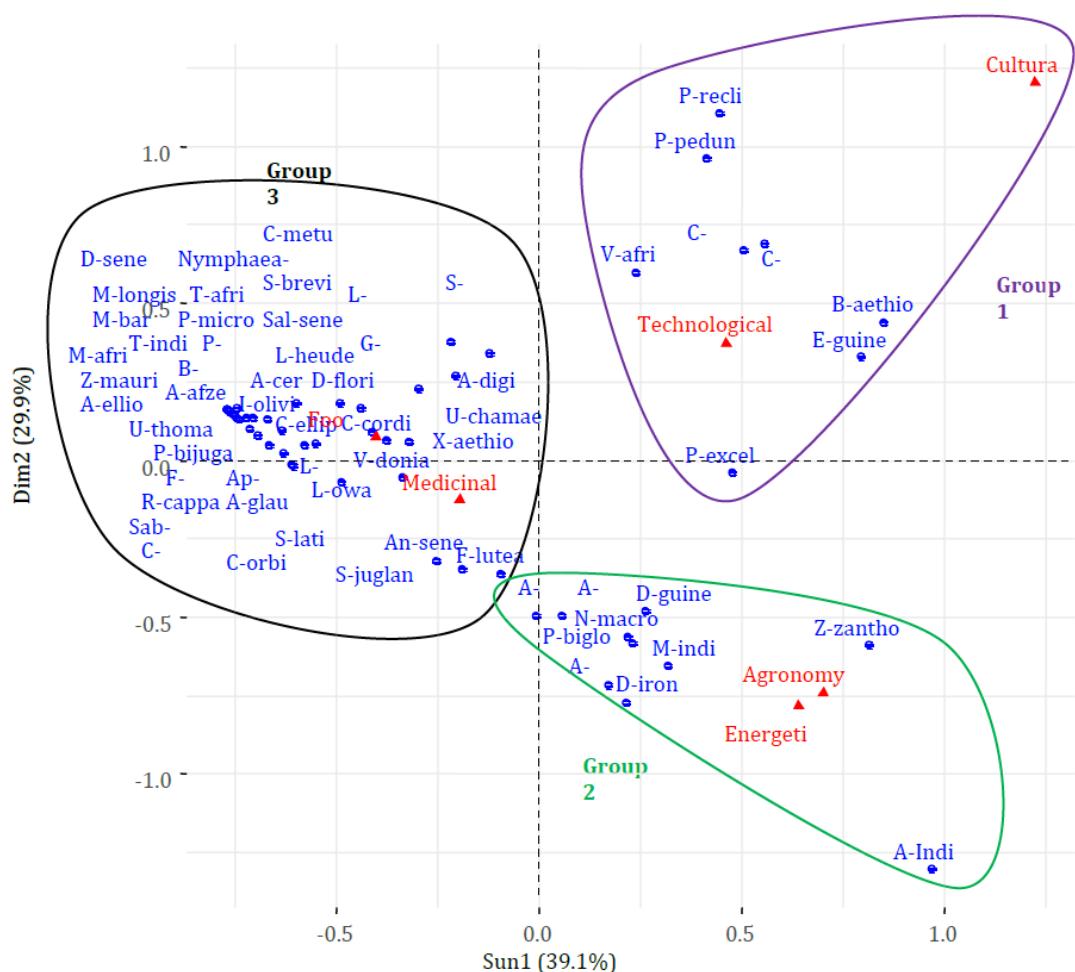
Figure 2. Factoral Correspondence Analysis (**FCA**) of the matrix of 62 species X 6 use categories

The consensus factors are very high for the six defined use categories. They are between 0.9 and 0.8 (**Table 4**). This shows that the plant species used and their use modes in the different Diola communities vary very little. Species use is most harmonious in food, cultural, and energy categories, where the consensus factor is 0.98-0.97. The agronomic category, which is strongly marked by female activity, has the lowest consensus factor at 0.89.

Table 4. Use and their category consensus factor (ICF)

Use category	Number of citation	Number of Species	ICF
Food	3128	62	0.98
Energy	943	28	0.97
Technological	716	40	0.94
medicinal	678	53	0.92
Cultural	325	8	0.98
Agronomic	85	10	0.89

In total, with regard to species use in the context of use value, use categories, organs used, our results show that the local population harvests different organs for multiple uses. *Elaeis guineensis, Borassus aethiopum*, *Mangifera indica*, *Neocarya macrophylla* , *Parkia biglobosa*, *Anacardium occidentale*, *Ceiba pentandra* , *Parinari excelsa* , are the most used species for the daily needs of the local population.

4. Discussion

Our results indicate 62 edible fruit species distributed in 31 families and 54 genera. They present a good generic and specific diversity compared to that of the 75 fruit species belonging to 35 families in the Séguéda region (Ambé, 2001). The results show a dominance of *Apocynaceae* and *Annonaceae*, and confirm those obtained by

(Ambé, 2001) and (Ouattara *et al* ., 2016).

Among the species studied, *Elaeis guineensis* (12.24) and *Borassus aethiopum* (7.56) have the highest use values with a relatively high number of use categories and organs used. *Elaeis guineensis* has 6 categories and 6 organs, *Borassus aethiopum* 5 categories and 5 organs. These two species are therefore highly sought after by the populations due to their high socio-economic and cultural values. They are used in the cultural field as well as in profane and sacred rites. Moreover, these species are an essential link in technology (construction of houses, production of means, etc.) and their products are abundantly consumed throughout the sector.

The *Anacardiaceae* which come in second position, when referring to use value, are essentially represented by *Mangifera indica* (3.74) with 5 categories and 6 organs and *Anacardium occidentale* (3.5) with 5 categories and 5 organs. These two species are of great economic importance, in particular *Anacardium occidentale,* the seeds of which have a high value in national and international markets as well as its alcoholic juice which is highly prized during public ceremonies and events (Djihounouck, 2018). This alcoholic juice is a substitute for palm wine in winter periods when it is scarce.

The results do not show a close proportionality between use categories, organs used and use value. The use of a species depends on its socio-economic importance, availability and accessibility. Therefore, the use value of a family is not proportional to its specific diversity as pointed out by Guèye (2012), Djihounouck *et al* . (2019). In addition, the species *Elaeis guineensis, Borassus aethiopum* , *Neocarya macrophylla* , *Parkia biglobosa* , *Anacardium occidentale*, *Ceiba pentandra* have significant use values between 12.24 and 3.23. The level of exploitation of these species by the local population has been highlighted by Dossou (2010), Lougbegnon *et al* (2011), Diatta (2016) who have shown that the importance given to a species depends on its capacity to meet the needs of the populations in the different use categories. *Borassus aethiopum* has a high use value and paradoxically, it is not abundant in our study area. When a species is not abundant and has a high use value, this means that it is under strong pressure as pointed out by Camou-Guerrero *et al* . (2008), Dossou (2010).

Our results show a certain homogeneity of uses of plant species in the *Kasa* area with a high consensus factor (ICF) for all use categories. They show six categories of use among the Diola populations in the *Kasa* area. These are: food, medicinal, technological, agronomic, energetic and cultural.

Food, energy, technological and medicinal categories are the most important in terms of citation with 3128; 943; 716 and 678 respectively. These results are comparable to those obtained by Galeano (2000) among the forest communities in Colombia, where he noted a high citation index for the "food" and "medicinal" categories. These results show that subsistence needs are the primary concern of the populations that exploit plant species. The medicinal category complete the medical centers and districts, which can explain its position.

The agronomic category has the lowest ICF (0.89) as information in this area is mainly held by women, who are not the priority target of the survey. Furthermore, the ICF for the medicinal category is the second lowest (0.92) since only traditional healers and a few initiated people have knowledge of the use of plants.

These results confirm the high value of the ICF for the different use categories of plant species in arid and semi-arid zones of Africa (Gning *et al.* 2013; Ayantunde *et al.* 2009; Cheikhyoussef *et al.* 2011). The ICF provides information on the good knowledge of species exploited by local populations on the one hand, and on natural resources important for the survival and well-being of rural populations on the other hand (Gueye, 2012). The rural population retains a fairly homogeneous knowledge of the uses of plant species transmitted from generation to generation through oral tradition. This knowledge could be a basis for local development policy.

The food category covers the activities of gathering and consumption of plants. All of the species inventoried are food, but their importance varies according to their frequency of citation by informants. Of the 574 citations for the 7 organs used in this category, *Elaeis guineensis* and *Nymphaea* spp. are the most frequently cited with 29% and 27% respectively, followed by *Borassus aethiopum* 21%, *Landolphia dulcis* 20% and *Adansonia digitata* 17%.

The energy studied is that which comes from firewood of woody species, in general, or from charcoal. It covers 42% of the species inventoried. This high frequency of citation reveals a significant energy demand by the populations and the diversity of species mobilized to meet this need. This category includes the priority activities of rural women, most of whom are housewives. Carrière *et al.* (2005) showed that among the Betsileo of Madagascar, firewood is the main category of useful plants for domestic use harvested in post-agricultural recruits and ranks first ahead of other uses such as pharmaceuticals, craft and construction.

The technological category concerns the making of means and includes 63% of species. The species *Elaeis guineensis* and *Borassus aethiopum* have the highest citation frequencies with 49% and 40% respectively and are

therefore the most used in the technological field. Their leaves are used for construction (house roof, hut, fence, etc.) and for crafting service products (brooms, baskets, mats, fish traps, basketwork, furniture, fibers, ropes, benches, belts to climb palm trees, ...) ; their trunks or stipes are used to construct bridges, beehives, dikes and habitats (pillar, frame, ceiling, roof, hut). These results confirm those of *Sambou et al* . (1992) and Blinch (2002). In addition, palm leaves and stipes give these species a high market value (Johnson, 2010).

The medicinal category represents 82% of the species inventoried. This study has enabled us to identify 96 pathologies among the *kasa* populations. The species frequently cited by the populations for the treatment of pathologies are: *Mangifera indica*, *Elaeis guineensis*, *Landolphia dulcis*, *Parkia biglobosa* and *Xylopia aethiopica*. The frequency of use of a species for disease treatment is an index of reliability of its effectiveness. Some authors even argue that plant species used repeatedly by the population in the medical field are generally effective and interesting in the search for bioactive molecules (Trotter & Logan, 1986; King *et al.* , 1996; Guèye, 2012). The fruit species used in the *kasa* have multiple medicinal uses except *Drypetes floribunda*, *Mammea africana*, *Atroxima afzeliana* , *Nymphaea spp* , *Cucumis metuliferus* , *Tamarindus indica* , *Annona glauca* , *Diospyros ferrea* which are only used to treat a single pathology.

The cultural category represents 12% of the species. It covers sacred or profane rites. The leaves of *Elaeis guineensis* and *Phoenix reclinata* are used in dancing initiation ceremonies. *Elaeis guineensis* provides brooms that certain fetish leaders always hold as a sign of identification at the sacred throne and its traditional wine commonly called "bunuk" is used for worshipping the fetishes traditionally called *bəkin* in order to enter into communion or set a contract with the ancestors and the gods (Loubelo, 2012). *Borassus aethiopum* is used as a symbol of prohibition to non-initiated people in a festivity or of recognition to a heritage or in a traditional dance or to create coffins. *Psychotria peduncularis* is used for blessings. *Ceiba pentandra* is used to create coffins often with the stem of *Carapa* Aubl. spp. also reported by Djihounouck (2010).

The agronomic category concerns 15% of the species. The leaves of *Mangifera indica* and *Ceiba pentandra* , and the fruits of *Parkia biglobosa* are often used as fertilizers for cultivated land. Evaluation of the impact of fertilization by the néré (*Parkia biglobosa*) and shea (*Vitellaria paradoxa*) on sorghum seed yields has shown an increase of 50 - 70% in Burkina Faso (Kessler, 1992).

5. Conclusion

This study identified the needs of the populations in relation to the 62 fruit species exploited in the *Kasa* area and highlighted the relationship between these species and the needs of the populations. The various products derived from these species have different uses grouped into six categories. These uses have made it possible to understand the importance of these resources for the local population in all areas of life. The uses of fruit species are relatively homogeneous for the different categories; however, they are more marked for food needs, followed by those of energy, technology, medicine, agronomy and culture. The use values, categories and organs used obtained allowed the identification of the most important species for the populations. In the *kasa* area, these are *Elaeis guineensis*, *Borassus aethiopum, Mangifera indica*, *Neocarya macrophylla*, *Parkia biglobosa* , *Anacardium occidentale, Ceiba pentandra* , *Parinari excelsa* , Thus, the estimation of the threat to these species by the use value assessed through harvesting has defined these species with the exception of *Elaeis guineensis* . This species has been little affected by human activities because of its strong predominance in the forest. The study reveals 7 parts of the plants exploited (fruit, wood, leaf, bark, root, flower and exudate) with a preference for fruits with food use. For a sustainable management of these non-cultivate edible and multiple-use fruit species, it is necessary to observe the population dynamics of the exploited species and involve local users in the resource, especially in the search for income.

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Annex: List of plant species used (abbreviated) for AFC

Allophyllus africanus (A-afri)	*Drypetes floribunda* (D-flori)	*Passiflora foetida* (P-foeti)	*Allophyllus africanus* (A-afri)	*Drypetes floribunda* (D-flori)	*Passiflora foetida* (P-feti)
Atroxima afzeliana (A-afze)	*Dialium guineense* (D-guine)	*Pseudospondias microcarpa* (P-micro)	*Atroxima afzeliana* (A-afze)	*Dialium guineense* (D-guine)	*Pseudospondias microcarpa* (P-micro)
Aframomum cereum (A-cer)	*Detarium senegalense* (D-sene)	*Psychotria peduncularis* (P-pedun)	*Aframomum cereum* (A-cer)	*Detarium senegalense* (D-sene)	*Psychotria peduncularis* (P-pedun)
Adansonia digitata (A-digi)	*Elaeis guineensis* (E-guine)	*Phoenix reclinata* (P-recli)	*Adansonia digitata* (A-digi)	*Elaeis guineensis* (E-guine)	*Phoenix reclinata* (P-recli)
Aframomum elliotii (A-ellio)	*Ficus capensis* (F-cap)	*Ritchiea capparoides* (R-cappa)	*Aframomum elliotii* (A-ellio)	*Ficus capensis* (F-cap)	*Ritchiea capparoides* (R-cappa)
Avicennia germinans (A-ger)	*Ficus lutea* (F-lutea)	*Synsepalum brevipes* (S-brevi)	*Avicennia germinans* (A-ger)	*Ficus lutea* (F-lutea)	*Synsepalum brevipes* (S-brevi)
Annona glauca (A-glau)	*Gardenia erubescens* (G-eru)	*Sorindeia juglandifolia* (S-juglan)	*Annona glauca* (A-glau)	*Gardenia erubescens* (G-eru)	*Sorindeia juglandifolia* (S-juglan)
Azadirachta indica (A-Indi)	*Icacina oliviformis* (I-olivi)	*Sarcocephalus latifolius* (S-lati)	*Azadirachta indica* (A-Indi)	*Icacina oliviformis* (I-olivi)	*Sarcocephalus latifolius* (S-lati)
Anacardium occidentale (A-occi)	*Landolphia dulcis* (L-dul)	*Spondias mombin* (S-mom)	*Western anacardium* (A-occi)	*Landolphia dulcis* (L-dul)	*Mombin spondias* (S-mom)
Annona senegalensis (An-sene)	*Landolphia heudelotii* (L-heude)	*Saba senegalensis* (Sab-sene)	*Annona senegalensis* (An-sene)	*Landolphia heudelotii* (L-heude)	*Saba senegalensis* (Sab-sene)
Aphania senegalensis (Ap-sene)	*Landolphia hirsuta* (L-hirsu)	*Salacia senegalensis* (Sal-sene)	*Aphania senegalensis* (Ap-sene)	*Landolphia hirsuta* (L-hirsu)	*Salacia senegalensis* (Sal-sene)
Balanites aegyptiaca (B-aegyp)	*Landolphia owariensis* (L-owa)	*Treculia africana* (T-afri)	*Balanites aegyptiaca*	*Landolphia owariensis*	*Treculia africana* (T-afri)

			(B-aegyp)	(L-owa)	
Borassus aethiopum (B-aethio)	*Mammea africana* (M-afri)	*Tamarindus indica* (T-indi)	*Borassus aethiopum* (B-aethio)	*Mammea africana* (M-afri)	*Tamarindus indica* (T-indi)
Cola cordifolia (C-cordi)	*Monanthotaxis barteri* (M-bar)	*Uvaria chamae* (U-chamae)	*Cola cordifolia* (C-cordi)	*Monanthotaxis barteri* (M-bar)	*Uvaria chamae* (U-chamae)
Calamus deerratus (C-deer)	*Mangifera indica* (M-indi)	*Uvaria thomasii* (U-thoma)	*Calamus deerratus* (C-deer)	*Mangifera indica* (M-indi)	*Uvaria thomasii* (U-thoma)
Chrysobalanus ellipticus (C-ellip)	*Macrosphyra longistyla* (M-longis)	*Voacanga africana* (V-afri)	*Chrysobalanus ellipticus* (C-ellip)	*Macrosphyra longistyla* (M-longis)	*Voacanga africana* (V-afri)
Cucumis metuliferus (C-metu)	*Neocarya macrophylla* (N-macro)	*Vitex doniana* (V-donia)	*Cucumis metuliferus* (C-metu)	*Neocarya macrophylla* (N-macro)	*Vitex doniana* (V-donia)
Chrysobalanus orbicularis (C-orbi)	*Nymphaea*-spp	*Xylopia aethiopica* (X-aethio)	*Chrysobalanus orbicularis* (C-orbi)	*Nymphaea* -spp	*Xylopia aethiopica* (X-aethio)
Ceiba pentandra (C-pentan)	*Parkia biglobosa* (P-biglo)	*Ziziphus mauritiana* (Z-mauri)	*Ceiba pentandra* (C-pentan)	*Parkia biglobosa* (P-biglo)	*Ziziphus mauritiana* (Z-mauri)
Celtis toka (C-toka)	*Pancovia bijuga* (P-bijuga)	*Zanthoxylum zanthoxyloides* (Z-zantho)	*Celtis toka* (C-toka)	*Pancovia bijuga* (P-bijuga)	*Zanthoxylum zanthoxyloides* (Z-zantho)
Diospyros ferrea (D-fer)	*Parinari excelsa* (P-excel)		*Diospyros ferrea* (D-fer)	*Parinari excelsa* (P-excel)	

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