Update February 2023

Assessing the potential for the development of business in four non-timber forest products from the tropics

Content

Client

Name	Precious Forest Foundation
Contact person	Jeanne Ehrensperger
Address	Lagerstrasse 33, 8004 Zürich, Zwitserland
Telephone	+41 44 299 95 95
Email	ehrensperger@precious-forests.foundation
Website	https://precious-forests.foundation/en/

Form International B.V.

Contact person	Tieme Wanders
Address	Eijerdijk 87 8051 MS Hattem Netherlands
Telephone	+31(0) 384448990
Fax	+31(0) 384448991
Email	info@forminternational.nl
Website	www.forminternational.nl
Author	Esther Boer, Tom Durang, Ronja Knippers, Sicco Stortelder, Tieme Wanders, Cathrien de Liagre-Bohl (UEBT)
Document version	4
Date of document	03-11-2021
Reference	NTFPV4

1. Executive Summary

The harvest of NTFPs by sustainable forest managers can financially support sustainable forest management. The objective of the report is to explore the economic potential of some of these NTFPs and to see if, and how these species can be used as an additional income stream to strengthen the economic viability of sustainable forest management in the tropics. This study builds on the recent work of Jürgen Blaser (see Blaser et al. 2021) that also looked at multiple-use management of NTFPs and timber, and provides further research into the various aspects and economic prospects of four identified NTFPs.

In this document, various NTFPs in the tropics are considered based on a set of success factors. Four promising NTFPs were selected: African walnut (*Coula edulis*), aguaje (*Mauritia flexuosa*), dammar gum (various species) and bush mango (*Irvingia gabonensis*, *I. tenuinucleata*). These NTFPs were chosen in such a way that the tropics of Africa, South-America and South-East Asia are all represented. The market potential of these products for forest managers is discussed in detail on resource availability and sustainability, the harvest and value chain, market size and developments, potential off-takers, trade volumes and routes, legal aspects, success factors for SFM operators, ethics and certification and a SWOT analysis. Furthermore, a business case is hypothesized for the four selected NTFPs. Through these aspects, we determine whether there is a viable and profitable case for harvesting these NTFPs in sustainable logging concessions in the tropics.

Aguaje

Aguaje is a palm fruit from *Mauritia flexuosa*, which presence throughout South America. *Mauritia* is important for fauna, providing food, nest sites and habitat. It is considered a hyper-keystone species in the Amazon. The uses of aguaje fruits includes food, drink, liquor/wine, sugar, animal feed and cosmetic oil. Due to its nutritional value, aguaje is marketed as a “superfood”.

The palm tree is widely disbursed in both the Amazon and Cerrado ecosystems and Brazil, Peru, Venezuela and Colombia all harbour this species. In Peru alone, estimates are of 5.3 million hectares of *Mauritia* swamp forests, with density ranging from 35-735 tree/hectare, and production from 1.5 to 15 t/ha/y.

In the Amazon, an individual is reported to gather approximately 25 kg of fruit a day. In Peru, wild female plants are commonly felled to collect fruits. This overexploitation of *Mauritia* trees has led to a male-biased population and population degradation. In Brazil, aguaje fruits are generally collected on privately owned lands from the ground or through flower stalks cutting. High-yielding trees are usually unproductive for the following 1-2 years.

In the department of Loreto (Peru), aguaje is transported over rivers to the commercial centre of Iquitos together with timber. In Brazil, fruits are mostly processed at the household level.

The market for *Mauritia* is mostly focused on local consumers, although oil for cosmetics is sold (inter)nationally. More historic prices were found for Peru in the range of US$ 0.07 to US$ 0.5 kg, now likely higher. In Peru, the market size for aguaje is 164,000 tonnes of fruit (worth US$ 16.4 million). Average yearly export is approximately 150 tonnes.

In Brazil, some açai harvesters turn towards this crop outside of the major açai harvest season. The market is growing in size and value and is expected to keep increasing each year. The cosmetics industry dominates the purchase of aguaje in Brazil. The oil is mostly bought directly from the communities at relatively high prices.

Little information is available on the international trade volumes and routes of aguaje-derived products. Statistics from Peru show an annual average export volume of US$ 1.4 million. There is also a European market for the oil and supplements.

The legislation on the harvest of NTFPs in Peru depends on the type of land use. For regular forest concessions, the harvest of NTFPs should be possible (but possibly costly due to the need to adjust management plans). In Brazil NTFPs are widely exploited, but there is no clear legislative framework for the management of NTFPs. In terms of certification, aguaje oil is certified by companies like IMOcert and Ecocert in Brazil that guarantee a low environmental impact and good social conditions. Aguaje is also certified by UEBT.

A hypothetical business case for Aguaje in which 1,000 hectares of Aguaje is harvested and processed can lead to US$ 1-2 million in revenues and interesting levels of profit. There are however important barriers for SFM companies to overcome, including the low price for unprocessed fruits, logistics, labour costs and intensity, overlap with timber season, limited market size and competition from other Amazonian oils.
On the other hand, we see that the amount of aguaje-dense hectares of forest needed is relatively small compared to the typical size of an SFM concession. This would possibly allow sourcing within forests nearby existing infrastructure. The first step for an SFM businesses to analyse the potentiality of a business case is understanding the abundance, access and type of aguaje present in the concession.

We see potential for agauje to be marketed in the international cosmetics and food (supplement) market, with oil and extracts as having most promising value chain potential. This is helped by the story-telling potential of aguaje as a ‘superfood’ in the global North.

Coula edulis

Coula edulis is a tree native to tropical western Africa. It is common in forest management units of Cameroon, Gabon and both Congos (densities of 1,5-4 trees/ha). Fruiting takes place between December and April. From the fruits, the Coula nut can be extracted, which is appreciated for its taste and texture. The nuts are locally collected and consumed in high numbers, both raw or roasted. Most collected nuts are auto-consumed, although some are sold. The nut yields a yellowish oil. As Coula nut oil is higher in oleic acid than all alternatives, it could be an interesting candidate for commercial development as a niche culinary oil.

It takes a person five hours to collect, bring home and crack 45 kilograms of fruits. The result is nine kilos of cleaned nuts. One kilogram of cleaned Coula nuts is worth about USD 1,17 on village markets and USD 2,34 in city markets. However, households derive little cash income from the sale of Coula nuts. Annual expected production is ~44.4 kilograms fruits per hectare of forest. Getting the 45 kilo of fruits (giving the nine kilos of cleaned nuts indicated to be achievable in five hours work) then involves collecting all nuts from at least one hectare (as it is unlikely that a tree drops all its nuts at once, in reality a larger area will have to be searched several times).

If all nuts were collected from a 300,000 hectare forest concession the sums would amount to 2,640 tonnes of cleaned nuts earning about USD 6.17 million if brought to the city market and if that market could adsorb the production. Per kilometre of road an area of 800 hectares can be accessed, potentially yielding around seven tons of cleaned nuts.

Comparing the prices obtained in villages with prices for cashew in other areas, we see that a kilo of raw cashew nut costs about USD 3.07/kg in Ghana in June 2020. The farm gate price was reported to be USD 0.66/kg. This farm gate price would be a good benchmark for Coula nuts of which the flesh is removed but which have not been cracked. The price of processed cashew nuts can attain about USD 4.68/kg.

In terms of grading checks and chemical checks for nuts in international trade, none are anticipated to be a particular challenge for Coula nuts.

Coula edulis is currently traded in the national markets of the countries where it is produced. Literature shows that auto-consumption is high, and that only a small portion of the produce is actually sold in town markets. *Coula edulis* is not currently traded in the international market. The production potential is enormous, however: 44,400 tons of cleaned nuts with a potential value of around 45,000,000 USD.

Hired labour will result in a similar cost price as purchase in a village. In countries were salaries are low, the resulting price for the raw product will be lower.

Regarding tax and transport, a similar system as for cashew and cocoa can be employed. The cost of conditioning and packing is then relatively modest and may be around USD 1.17/kg.

In the forest legislation of Cameroon the use of the nuts is granted to the people living close to the forest. In Gabon, commercial collection of NTFPs requires a permit from the director general of the forestry department.

A hypothetical business case for Coula shows that collection by the SFM company can generate a net income of USD 15,990 for 50 tons. If the collection is left to the buyer, people in the villages can earn USD 0.65 - USD 0.22 per kg, which corresponds to payment of a minimum wage.
Areas reserved for villages are off limits for NTPF collection, and this needs to be carefully checked. When collecting the needs of local wildlife also need to be taken into account.

Market growth could be supported by commercialising Coula oil as a culinary oil. This will depend on EU Novel Foods approval. Neither the oil nor the nut have been evaluated for compliance. It would also be worth investigating the use of the oil as a cosmetic ingredient.

Dammar gum
Dammar gum is a resin extruded from the tree family *Dipterocarpacea*, which are found throughout South-East Asia and are also important timber species. *Agathis dammara* (*Araucariaceae*) also produces dammar gum. Resin is produced by incisions in the tree, although some is gathered in fossilized form. Resin production varies from tree to tree, ranging from a 2-30 kg/year/tree.

Dammar gum is used as incense, in varnishes, lacquers and paints, as a food additive, a clouding agent, to mount biological sections for examination under the microscope, as a water-resistant coating for pharmaceutical tablets, in batik dyeing, in coloured printing inks, and to make beeswax food wraps.

Many dammar-producing trees are endangered as a result of overcutting, extensive illegal logging, and habitat conversion. Yet, forest management practices developed by local people have been efficient in fulfilling household needs guaranteeing the sustainable use of dammar trees. As such, dammar is often harvested from agroforests, which maintains biodiversity and ecological functions.
The promotion of tapping of only high-grade resin is a good strategy to further promote sustainable harvest practices. This can be aided by enrichment planting.

The wide array of applications of dammar gum is driving global dammar gum market growth. Dammar agroforests are developed in Sumatra, Indonesia, to cater for the growing demand, including for export to India for incense. The U.S. also holds a significant share in the dammar gum market, owing to a high demand for dammar gum in the food and paint industry.

The most pure and clear batches of dammar are sold as cat eye resin. Black resin or copal resin is the next dammar gum grade. The cheapest grade of dammar gum is stone resin, which is fossilized.

There is no specific season connected to dammar harvesting. This provides concession managers with options regarding collection times and intensity. However, most Dipterocarps are prized timber species. Concession holders could experience interference between timber and dammar production individuals. Revenues will be maximized if trees for resin production are chosen based on resin grade and amount produced.

In Indonesia, NTFPs in protected areas can only be collected by local people. A permit is needed to collect these NTFPs. NTFP collection in production forests is allowed but needs to benefit local communities and is subject to CITES regulation. Within the right system, concession holders and local communities can both benefit, which could be substantiated through certification.

Dammar gum can provide an additional revenue stream for forest owners. Potential revenue is subject to various factors concerning quality of dammar resin, presence of suitable species, distribution of diameter at breast hight and availability of sales channels. A hypothetical business case for Indonesia shows a positive picture for dammar collection in forest concessions, even with only 0.6 suitable trees per hectare. In Malaysia the living wage is much higher than in Indonesia. Still, assuming the same storage and transportation costs, dammar resin collection could be a viable business venture for sustainable forest managers.

Bush mango

Irvingia gabonensis is native to the lowland rainforests of Central and Western Africa. It produces large, mango-like fruits. The main use of the fruit, commonly known as bush mango or African mango, are the seed kernels (dika nuts), which can be used as a condiment and to thicken soups and sauces. Oil is harvested from the seeds which can be used for cooking and cosmetics. The fruit pulp is edible and produces a black textile dye. *I. tenuinucleata* (synonym of *Irvingia wombolu*) is morphologically and ethnobotanically similar, although the pulp is not eaten due to bitterness.

Outside of Africa, *Irvingia* spp. is mostly used as a dietary supplement due to its potential as a weight-loss stimulant.

Data on bush mango densities is scarce. In general, mean *Irvingia* densities range between 1-2 trees per hectare, the vast majority of which are *I. gabonensis.* Apart from their occurrence in the wild, bush mango trees are also widely nurtured and cultivated in home gardens, farm lands and in agroforestry systems. Average seed kernel yields per tree per season are 18-25 kg.

Bush mangoes are an important foodstuff for many rainforest animals. Threats to the conservation of bush mango trees are mild, but the effects of bush mango harvest on animals should be taken into consideration during organisation of large-scale *Irvingia* spp. harvest.

Bush mangoes are collected both from farm land and home gardens as well as from primary and secondary forests. The drying of *Irvingia* kernels takes approximately 2-3 days. Thereafter, they can be stored for months. In general, bush mango producers in Cameroon reap a low margin on their produce.

In Cameroon, there are villages that have developed local governance around the collection of bush mangoes. Moreover, an exploitation permit is compulsory for large-scale exportation of NTFPs. In Nigeria, where the bush mango trade is more developed, traders are required to register with the bush mango association before they are allowed to sell their produce. In Gabon, commercial collection requires a permit issued by the director general of the forestry department.

There is much opportunity to widen the market for *Irvingia* outside of Africa. The pleasant taste and hypothesized health benefits of dika nuts could mean that whole nuts could be successfully marketed in Europe and beyond. Moreover, their potential health benefits could be capitalized upon by the pharmaceutical industry

Bush mango prices are dependent upon the quality of the seed kernels. There are four general quality gradings for bush mango seed kernels which attract different market prices. The average cost price fluctuates throughout the harvest season between 1200-4400 CFA/kg.

The collection of *I. gabonensis* could pose an interesting opportunity for forest managers in the lean season, but the success of such ventures will be dependent on the availability of storage space, equipment and infrastructure. Additionally, it will have to be carried out by an alternative workforce, given that forest workers will generally be unavailable. SFM operators could maximize their margin on the bush mangoes by saving part of their harvest so that they can be sold in the off-season and fetch a higher price.

A simplified business case for *Irvingia* is hypothesized. Given a forest concession of 20,000 hectares, 110,000 tons of fruits and 450 tons of seeds are available which could generate USD 1,316,000 or 718 million CFA (USD 65.81 or 35,900 XAF per hectare). Labour costs would be 1,181 million CFA (~USD 2,106,000) for Cameroon, and 486 million Naira (~USD 1,170,000) for Nigeria. That does not yet take into account costs for packaging, transport, equipment, etc.
This shows that, even with only assuming labour costs, *Irvingia* harvest in forest concessions is not a profitable venture. However, if the price of *Irvingia* seeds is currently higher than

assumed here, that would open up possibilities for Nigeria and countries with similar living wages.

Discussion

The findings from our study demonstrate that several of the NTFPs have potential in the market or are already being marketed to some extent. Aguaje, Coula and dammar all have the potential to be a profitable side-venture for sustainable forest managers. For Aguaje-derived products, a significant (inter)national market already exists. For Coula, a nut trader has shown serious interest to study the product in more detail. Dammar gum production has the potential to generate considerable revenue from concession forests even at low densities and can help conserve threatened Dipterocarp species while supporting local communities. For bush mango, it was found that the collection of fruits by employees paid a living wage is costly, and the success of such a venture would depend heavily upon the price at which the kernels can be sold.

2. Introduction

The business case for timber production has been under pressure since more demands and requirements are put on companies to sustainably manage the forest, which has increased production costs. At the same time, sustainable management of forests has slowly become the norm in most areas in the tropics. Additionally, the lucrative trade in unprocessed logs has been curtailed progressively. Timber producers turned forest managers have seen their margins reduced due to these events.

Innovative ways are needed to support the business case for sustainable forest management. Payment for Ecosystem Services is one possibility to increase the earnings for forest managers and this is slowly being developed and rolled out. Harvesting a broader diversity of products from the forest would be another possibility to increase earning while maintain a certain level of costs for management. Possibilities have been identified in Lesser Known Timber Species, and the marketing of NTFPs is another potential earner for forest managers. With this project we want to identify a selected number of NTFPs with high potential and assess their business case so forest managers can easily assess the viability of collecting and processing these

This study builds on the recent work of Jürgen Blaser (see Blaser et al. 2021) that also looked at examples of NTFPs that can be managed alongside timber under a multiple-use management approach. Blaser's report identified well-established and promising NTFPs that grow in tropical forests, as well as three interrelated ways to move forward on multiple-use forest management with timber and NTFPs. Among its conclusion's, they found that the compatible management of timber and NTFPs is inherently multifactorial and context-dependent and that further research is needed to determine the economic case for multiple use forests.

This current study is an example of such further research and goes into detail on the various aspects and economic prospects of four identified NTFPs. In this document, various NTFPs in the tropics are considered based on a set of success factors. Four promising NTFPs were selected: African walnut (Coula edulis), aguaje (Mauritia flexuosa), dammar gum (various species) and bush mango (Irvingia gabonensis, I. tenuinucleata). These NTFPs were chosen in such a way that the tropics of Africa, South-America and South-East Asia are all represented. The market potential of these products for forest managers is discussed in detail on resource availability and sustainability, the harvest and value chain, market size and developments, potential off-takers, trade volumes and routes, legal aspects, success factors for SFM operators, ethics and certification and a SWOT analysis. Furthermore, a business case is hypothesized for the four selected NTFPs. Through these aspects, we determine whether there is a viable and profitable case for harvesting these NTFPs in sustainable logging concessions in the tropics.

3. General introduction to NTFPs and multiple use forestry

3.1. Introduction to NTFPs

Non-timber forest products are products which can be harvested from the forest other than timber. Typically, these products are nuts, fruits, bark, resins, gums, fungi, leaves and flowers, but they can also be animal products. Although some of these products can only be harvested through destructive practises such as by the removal of bark or the cutting of rattan stalks, others such as nuts and fruits may be harvested with limited impact. In many of the forest concessions which are managed for timber, several such products are available, but few forest managers complement their business with the gathering and marketing of NFTPs.

NTFPs were economically important before the onset of synthesisation of rubbers, oils and gums. Their diminished importance in international trade after World War II meant that they became almost invisible in forest statistics, management, and policy. The FAO stopped publishing information on them in the 1970s. They were rediscovered in the late 1980s, provoking high hopes by many, suspicion by some, and a new research agenda on their potential role in the sustainable development of tropical forest regions (Sills et al. 2011).

With the resurgence of interest came also many claims that NTFPs on their own could be worth more than timber in forests. Moreover, NTFPs carry the reputation that harvesting them has little or no effect on the ecosystem. Early hopes that NTFPs would underpin rural livelihoods and rescue rural populations from poverty while providing them with a reason to protect and manage forests, led to exaggerated claims of economic potential (Lawrence 2003). Such claims conveniently neglect the effort it takes to put a product in the market and the often complicated paths a product takes before it reaches a paying customer. Belcher and Schreckenberg (2007) rightly warn that:

- Production is often dispersed and markets poorly developed,
- Markets are diverse and faddish, while product development takes long,
- Volumes available are typically small,
- Technological innovation for processing may be necessary,
- Barriers to entry to the market may be high,
- Certification is a mixed blessing,
- Intellectual property rights issues may block market access,
- There may be ecological consequences of harvesting.

In spite of these caveats, it is clear that many NTFPs have found a market and are traded with success. Examples are the Brazil nut (*Bertholletia excelsa*) and the Açaí berry (*Euterpe oleracea*). Some former NTFPs have become mainstream agroforestry products such as cocoa and rubber. Many potential products have not been properly studied and may present an opportunity to become successful contributions to the funding of sustainable forest management.

In this report we have selected likely candidates based on criteria that were inspired by successful NTFPs and by the need to select products that are almost exclusively found in forest management concessions. Four such products have been studied in detail. The list from which they came is longer, and it is possible that other products mentioned in the assessment matrix (Annex 1) are also good candidates for testing in the market.

3.2. Multiple use forestry and NTFPs

The harvesting and marketing of NTFPs can be an important element in multiple use forestry. In multiple use forestry, forests are managed for timber production, but also for conservation, climate regulation, water, socio-cultural uses and for the production of NTFPs. In the current management model for many forest management units, timber is the only source of income for the managers. The business case based on timber alone is not as robust as is needed to guarantee the long-term sustainable management. A series of bankruptcies in Cameroon in the past decade have shown this quite clearly. It is hoped that with the inclusion of other sources of funding such as climate finance, payment for other ecosystem services, premiums for biodiversity conservation, diversification of timber species harvested and traded and the inclusion of NTFPs in the forest managers portfolio, forest management companies can become more robust and continue to manage the world's forests sustainably.

It is possible that having various products and services in a company's portfolio leads to more efficient use of man power. This could for instance be because certain products are harvested in other seasons than timber. It is likely that this is different on the three continents. In South America companies are more used to harvesting trees during only a few months of the year, whereas in Africa the off- season is often only very short due to good road construction. Though the idea of new activities for the off-season sounds logical, it remains to be seen if personnel with certain specialisations such as tree felling can be asked to pick berries during the period of heavy rains when felling is not possible. Leave of personnel and maintenance activities are also usually planned during such periods.

Practicalities aside, the concept requires not only more knowledge on the part of the forest manager, but also has many legal implications. In Gabon and Cameroon for instance a timber concession grants the concessionaire access to timber on certain conditions. Not all timber trees are included (ebonies are considered special products warranting a specific license). The concession agreement does not grant the concessionaire rights to NTFPs, payment for ecosystem services or carbon income and negotiations will be needed to gain access to these. Examples are currently being explored. This fact has implications for the outcomes of the current study as well. Positive cases in Africa will for instance require negotiation with forestry ministries and with local communities to make clear agreements on access to the NTFP resource.

This means that, beside finding markets for diverse products and services, the concept of multiple use forestry depends on several other elements. As indicated, there is a political factor in areas where the forest owner is the state and only the rights to harvest timber have been granted. But from a business perspective also diversification can be a great challenge as it needs the creation of access to new and different markets with potentially perishable products.

For now, it seems though that knowledge on what is possible in the field of multiple-use forestry with NTFPs is needed to start up the processes of diversification. Forest managers need to be inspired by opportunities that show the value and benefit of using their forests in more ways than only for timber harvesting.

4. What would make a non-timber forest product successful?

In order to make well founded choices from the long list of potential NTFPs, a set of criteria was drawn up. The matrix in Annex 1 presents basic information on the NTFP in question and a rating for the success factors. In this section, the criteria we formulated are explained.

4.1. Found in logging concessions

As the aim of the study is to evaluate if the production and sale of NTFPs could be an element to improve the business case for forest managers, it is essential to evaluate if an NTFP is regularly encountered in forests managed for timber production.

4.2. Potential for production outside the forest

The potential to cultivate an NTFP outside of forests managed for timber production is a strength but weakness as well. In order to have exclusive access to a certain product, it would be favourable if it is difficult to cultivate or if the quality depends on it growing in a forest environment. The potential to produce a product in main stream agriculture will quickly stop the advantage for forest managers as production costs from agriculture will almost certainly be lower.

4.3. No prohibitive legislation

It is important to make sure that a forest manager can have access to a product legally. In some cases special licenses need to be obtained in order to be allowed to bring the product to market. It is also possible that the use of a product is reserved to people living close to or in the forest. In those cases, in addition to a permit, a compensation to local communities may also be required. There are also NTFPs which cannot be traded at all because of bans or other legal restrictions

4.4. Advantageous density-price relationship

Product that are naturally rare in the forest environment need to fetch high prices to make it worthwhile to collect them. The information on density is important in the evaluation of business potential, but also influences the risk of collection having a negative influence on the NTFPs population. Rarer commodities are more likely to be negatively affected.

4.5. Product known in international market

Products which are already known in the market are easier to develop further. Unknown products need much advertising and research. Even then, it is not certain that the market will accept it. Completely unknown products in the international market are better avoided.

4.6. Storability

Especially if a product is to be collected in remote areas, storability is important. As a consequence of this, products which do not perish easily have a better chance of coming from such areas. Interestingly, Açaí, which needs to be processed quickly and cooled or frozen in storage, is a successful NTFP. As such, this criterion is to be observed with care.

4.7. Few transformation needs

It is important to have a clear view of what is needed in terms of processing before a product can be brought to the market. Products which need much further processing will require additional investments on the part of the forest manager or may be sold at lower values to processing companies. It is also important to consider if a product needs water or energy for its transformation. In some cases, much water is needed for the rinsing of products in order to remove toxins, or much energy is needed for melting it for extraction. Such cases are less attractive, because they may create sustainability problems.

4.8. Unique properties

It is advantageous if a product is clearly different from other products to earn its place in the market. Products which are substitutes for existing products with exactly the same properties are difficult to scale up unless the price is competitive or the story potential is good.

4.9. Harvest systems

Some products can be harvested without causing harm to the plant producing it, such as fruits, nuts, flowers and most exudates. Other products such as the bark or the wood need the plant or tree to be cut or damaged in order to obtain it. Because this is associated with high risks for sustainability, NTFPs which depend on destructive collection techniques were not further considered in this study.

4.10. Possible certification

Markets increasingly rely on third party certification to have assurance that a product was produced with proper respect for people and the environment. The possibility to bring the product to market under a recognised label will enhance its chances of acceptance.

4.11. Sustainable, large scale production possible

A product which is not available in sufficient quantities to satisfy the market and for which the production cannot be increased will at some point encounter problems in the market. Many market parties do not wish to engage in the marketing activities and setting up supply chains if a product may not be sufficiently available or if availability is unreliable.

4.12. Favourable market trend

Markets are subject to trends. Colours (and hence dyes), types of food and even types of ingredients in non-food applications are subject to fashion and trends. Foods which have a name of being very healthy (so called superfoods) currently find a public that is curious and willing to try new products. This may provide an opportunity to create markets.

4.13. No competition from cheap substitutes

Products which can be substituted by cheaper products have more difficulty keeping a market share. This is clear when looking at sugar. Cane sugar or sugar derived from coconuts of from sugar palms are easily substituted and are only bought by clients specifically look for the exotic variety.

4.14. Story-telling potential

Analogous to FSC certification for timber or Fair Trade certification for other products, an interesting story giving the buyer a good feeling about the purchase can enhance the chances of a product in the market. Stories are also a danger. Facts behind the story may be checked and presented in a different story by the competition (as seems to be going on between “fair trade” and “on the way to slave free” chocolate).

4.15. No toxic relatives

Certain families of plants provide spices or fruits but have relatives that are toxic. Especially the Spurge (*Euphorbiaceae*) family is known for having toxic members. Even if a product is completely safe and harmless, it may be tainted by knowledge of people on toxic look-alikes.

4.16. Market access legislation/pharmaceutical regulations

Restriction to market certain products, for instance because the substance for which it is marketed needs pharmaceutical clearance, can hinder acceptance of a product and will make to path to successful marketing longer. If an NTFP is to be marketed for pharmaceutical properties, it is best to select those that have been tried and tested, to avoid having to invest in that process.

4.17. No IP rights

NTFPs that on which intellectual property has been claimed are more difficult to market.

5. Assessment of potential NTFPs

With the aforementioned criteria, a matrix was set up in which the NTFPs as put forward by Blazer et al (2021) (and a few additional products) have been analysed. From this so called long-list we selected 17 NTFPs to be discussed for the final selection:

- Açaí (*Euterpe oleraceae*),
- African walnut (*Coula edulis*),
- Aguaje (*Mauritia flexuosa*),
- Allanblackia (*Allanblackia* spp.),
- Andiroba (*Carapa guianensis*),
- Brazil nut (*Bertholletia excelsa*),
- Chicle (*Manilkara zapota*),
- Cocoa (*Theobroma cacao*),
- Cinchona (*Cinchona* spp.),
- Dammar (*Hopea odorata* and other species)
- Inoi nut (*Poga oleosa*),
- Kitul palm (*Caryota urens*),
- Rattan (*Calamus* spp., *Daemorops* spp.),
- Rubber (*Hevea* spp.),
- Sago (*Metroxylon sagu*),
- Bush Mango *(Irvingia* gabonensis, *I. tenuinucleata*) and
- Wild spinach (*Gnetum africanum*).

These products all are deemed to have potential. The list was then evaluated and discussed in order to come to a selection of four high-potential NTFP, with at least one for each major tropical region. We decided to leave out all species that have destructive harvesting needs (either bark removal or complete stem removal). These were Cinchona and Sago. Then there are products which are indistinguishable from plantation grown products such as Rubber, Cacao and Kitul palm. Also, there are products which are well established in the market such as Acaï, Brazil nut and Rattan. Finally, there are products that have little hope of expanding their current market such as Chicle and Andiroba. Some products are deemed too perishable such as Gnetum, which is also starting to be cultivated on an increasing scale. In the case of Allanblackia it was decided that it is already sufficiently studied.

The products chosen for further evaluation were:

- Aguaje (*Mauritia flexuosa*),
- African walnut (*Coula edulis*),
- Dammar (*Hopea odorata* and other species)
- Bush Mango (*Irvingia* gabonensis, *I. tenuinucleata*)

6. Assessment the potential business case for the selected NTFPs for forest management units

In this chapter the four chosen products are described regarding their use as a side-venture for sustainable forest managers. This includes a simplified business case based on available information to show financial viability.

6.1. Aguaje/Buriti (Mauritia Flexuosa)

6.1.1. Introduction of the species

Aguaje or buriti is the fruit that is harvested from the palm *Mauritia Flexuosa. Mauritia flexuosa is a* large single-stemmed perennial palm widely dispersed throughout South America. The palm's common English name is Buriti palm (lending from Portuguese), and is further known as moriche (Spanish), ité, miriti and canangucho (Colombia). The name Aguaje is the Peruvian name, derived from the name of palm swamps (*aguajales*). *Mauritia* grows up to 30-40 meters high and produces flower stalks up to two meters that support between 25-40 branches on which Aguaje grows (Horn et al. 2012). The female tree produces the fruit, but needs male trees for pollination (Koolen et al. 2018). The *Mauritia* starts developing fruits after 7 or 8 years and its production may live up to 40-50 years. Once fruit appears on the tree it last more than one year to fully ripen.

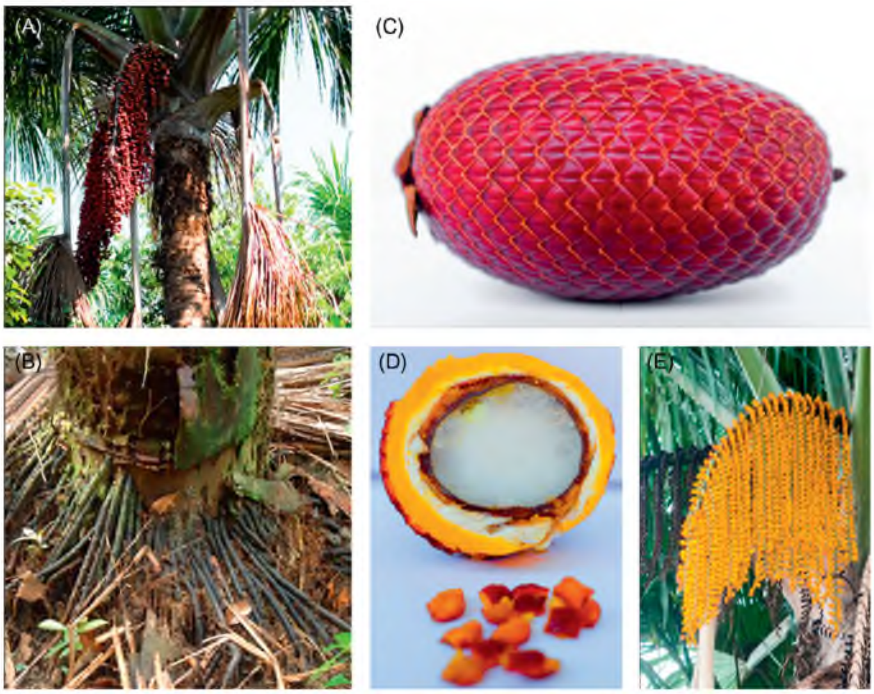


Figure 1: (A) Aguaje blossoms (B) Aerial roots of the Mauritia (C) Aguaje fruit (D) Cross-section of an aguaje fruit (E) Aguaje flowers (Picture taken from Koolen 2018).

Mauritia is an important palm for fauna, providing food, nest sites and habitat, and contributing to at least 940 vertebrate species, with 8 highly dependent on it and 28 threatened species, and some authors consider it a hyper-keystone species (van der Hoek 2019), and ecological historians referred to it as the 'Tree of Life' (Fernandes 2011). The palm is further found to likely play an important role in carbon accumulation for its wide root system, prevalence in waterlogged areas, and its role in the production of Amazonian peat (Virapongse et al. 2017).

The use of palm is multiple: fruits are eaten raw and the base for marmalade, juices, liquor, a fermented beverages and fluor, as well as digestive medicine. The palm heart is edible as vegetable, while the sap from the young, unopened inflorescences can be drunk, condensed for the sugar content, or fermented into palm wine. Local Aguaje products and markets have long been present in the Amazonian and savannah regions of Brazil, Peru, Bolivia and Venezuela. Due to its nutritional value, Aguaje is even marketed as a new "superfood" and sold in food products and drinks domestically and internationally (see e.g. Evergreen, 2017). From the fruit pulp oil and extracts are produced which are used as ingredient in cosmetics due to its various beneficial properties for the skin.[1] With the processing of the pulp a "cake" by-product is generated, which is sold locally as animal feed (SEMA 2019).

6.1.2. Resource availability and sustainability

Mauritia flexuosa is widely dispersed across South America, from Trinidad and Venezuela down to Brazil and Bolivia (*Figure 2*) (Ribeiro 2010). The palm prefers poorly drained or periodically flooded lands, but is present in both the Amazon and the Cerrado.[2] The palms often come in high-density clusters, and is considered hyper dominant and ranked 22nd of most abundant tree species in the Amazon Basin and Guinean Shield. Ter Steege (2013) estimates a total abundance of 1.5 billion palms (500 trees/ha), but this seems to overestimate *densities* and likely under-estimate the *amount* of hectares where *Mauritia* is occurring in significant densities. Other studies report between 35 and 735 adult trees/ha[1], with most studies showing densities below 200 trees/ha). In Peru alone there are 5.3 million hectares of *Mauritia* swamp forests, of which 5.0 million in the province of Loreto (Brokamp et al. 2011).

Considering the wide distribution in the whole Amazon (550 million ha) and Cerrado region (191 million ha), the total area could sum to tens, if not hundreds of millions of hectares. Reported sex ratios (male-to-female proportion) tend towards a higher male abundance, but this could also be the result of historical logging of the female plants. Furthermore, *Mauritia*

[1] See for more information on Aguaje's benefits e.g. AmazonOil 2021a.

[2] Studies from Brazil indicate different Mauritia variety exist in the Cerrado (Sampaio 2011), while other refer to the species growing in the Cerrado as *Mauritia Vinifera* (Galdino 2007), which is officially still considered a synonym for Mauritia Flexuosa (Plant list: http://www.theplantlist.org/tpl1.1/record/kew-122230). Further (genetic) studies on the existence of different species or varieties are needed.

is known to be polygamous, and can contain female, male and bisexual flowers (Koolen 2018). Most studies indicate a certain male: female ratio defining productivity, which we also assumed.

Figure 2: Distribution of M. flexuosa *in South America (Horn et al. 2018).*

In the flowering season, each palm has 4-8 flower stalks with each raceme containing 500-2000 fruits. Each fruit weights between 15 to 75 grams; with 800 fruits of 50 gram, and (a conservative) 4 flower stalks, this results in 800 * 0.05 * 4 = 160 kg of fruit per tree. Assuming a conservative 100kg/tree, per-hectare production ranges from 1.5 t/ha for low-density areas, up to 15 t/ha for very high-density areas (6.5 t/ha in Peru and 9.1 t/ha in Colombia are reported in natural forests, and 19.1 t/ha for plantations) (Manzi & Coomes 2009; Brokamp et al. 2011).

Table 1: Production estimate per stand density

Density	Trees/ha	Female trees/ha	Kg fruit/tree	Kg fruit/ha
Low	30	15	100	1,500
Normal	70	35	100	3,500
High	150	75	100	7,500
Very high	300	150	100	15,000

Assumptions: male-female sex ratio 1:1; a conservative 100kg of fruit per tree.

Destructive practices have been reported since the late 1980s when the fruit began to have economic value and market access, but seem to be mostly restricted to Peru. Female plants are commonly felled to collect the fruit. Estimates of felled trees to meet the market demand vary greatly between 17,000 and 200,000 trees per year – Peruvian studies generally assume felling is the common practice for harvesting – it is believed fallen fruits are difficult to process (Virapongse et al. 2017; "personal communications" with G. Freitas). This type of overexploitation of *Mauritia* trees has led to a male-biased population in many areas and the overall degradation of the *aguajales.* In Brazil, Aguaje fruits are generally collected from the ground and swamps after natural drop, or the flower stalks are cut by climbing the tree – a common practice far more sustainable than in Peru (Sampaio & dos Santos 2015) (Figure 3).

Figure 3: Left: an Aguaje palm forest or "aguajale" (Koolen, 2018) Right: climbing a Mauritia palm to harvest Aguaje, a sustainable harvesting practice (SEMA 2019).

Leaf production from the Mauritia palm is most developed in some districts of Brazil. Young leaves of the Mauritia palm are used for obtaining strips, for production of handicrafts, especially in Maranhão, Brazil. Furthermore, leaves are common for use as thatching material. The leaf harvesting through climbing the tree and cutting the leaves does not seem to affect growth or leave production.

6.1.3. Characteristics of harvest and value chain

<u>Harvest</u>

Most information on harvest and the value chain of Aguaje comes from Peru and Brazil. Aguaje can be harvested year-round in some swamp areas, but each region where aguaje grows has specific months which are considered best for. High-yielding Mauritia trees in one year are usually followed by one or two years of low productivity – studies indicate harvesters in Brazil leave trees unharvested for one year (Sampaio & Carrazza 2012).

Table 2: Main harvest seasons (based on Auqui, 2019; Sampaio & Carrazza 2012)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Brazil Amazon												
Brazil Cerrado												
Peru (Iquitos)												
Peru (San Martin)												

In Peru, aguaje is generally harvested from wild individuals by cutting down the tree, with most of *Mauritia* habitats are either open-access or are privately owned by smallholders (Sampaio et al. 2012). Although the fruit is commonly used at the household level and in some areas widely harvested, the *Mauritia* is not typically cultivated by smallholders, with some exceptions such as the community of Roca Fuerte (Manzi 2009). Research and initiatives show potential for monocropping and intercropping in agroforestry systems, and a dwarf variety has been identified as having high potential (Delgado 2007: Virapongse et al. 2017). Around Iquitos the main harvesting season of timber is from June to August, which partially overlaps with the main harvesting period for aguaje in this region. Both timber and aguaje are transported over rivers to the commercial centre of Iquitos.

In Brazil, harvesters of the fruit usually collect them from privately owned lands. Fruits that are used for local consumption, are mostly processed at the household level, whereas produce for the regional and national markets the fruits are processed at (local) processing plants. Oils are often prepared within communities through a cooking and extraction process, and subsequently bought by processing and trading companies. The harvest and processing of aguaje in Brazil is more professionalised than it is in Peru, in particular for oil production (see e.g. Sampaio 2011). For food products, aguaje oil requires purification, which is usually done in San Paolo because of infrastructural challenges. This results in a higher price for purified oil.

Sampaio (2011) reports that two people gather approximately one sack of 50kg in a day (25 kg/man day). Fruits need to be gathered within a few days, due to the high perishability. De Sousa mentions that in Abaetetuba, Northern Brazil, not all men are skilled for climbing and cutting, and people are being contracted for cutting fruits for US$ 0.84/palm. In Loreto, the demanding manual production is reported at 1.5 sacks/day, equal to 75 kgs (Rumbos 2019). Assuming a 'farm gate price' of US$ 0.10/kg, this equals 7.5 USD/man day in Peru, slightly below minimum wage of (230 US$/m)[3] in the formal economy.

6.1.4. Value chain & actual market size

The market for *Mauritia* products varies per region and is mostly focused on local consumers, although some products, such as fruit oil for cosmetics, are also sold nationally and internationally, especially from Brazil.

<u>Peru value chain</u>

The *Mauritia* fruit value chain in Peru is composed of primary collectors, intermediaries, wholesalers, street vendors, and retailers, and some companies processing fruits for pulp and in some cases oil (Virapongse et al. 2017). Women are often seen in prominent role in these markets, though mostly at the less profitable value chain activities. In Peru, two different varieties are distinguished, namely Aguaje Shambo, a more reddish-orange variety, thick mesocarp, often cultivated, higher priced and consumed as fruit, and Aguaje Posheco (also referred to as Aguaje Color or '*comun*'), with yellow pulp and reportedly traded in higher volumes, generally used for processing (See e.g. Brokamp 2011; Manzi 2009; Gamboa 2019).

[3]Derived from https://www.geovictoria.com/pe/sueldo-minimo-en-peru/, xe.com.

Harvesters typically sell their fruit to riverboat traders or to wholesalers in Iquitos. Fruit arrives from communities along the major watersheds of Loreto and through aggregation points like the port towns of Nauta and Mazan to the market in Iquitos, where the fruit is sold to local consumers for raw consumption or processing. The fruits are sold in sacks between 30-50 kg, which contain between 800-1,200 fruits (Horn et al. 2018). Only older reference prices were found for Peru in the range of US$ 0.07 to US$ 0.5 kg/fruit, with low prices in high season and vice versa. Transport prices in Iquitos are approximately 5 Peruvian soles/sack, or US$ 0.025/kg (~ 25% of value) (Nicho Pretell, 2018). Value of the pulp is estimated at 15-20 soles/kg, or 3.7-4.9 USD/kg in Peru (Echevarria et al. 2018). A community project supported that supplies to the large drink group AJE established prices at 30 Soles/ 40kg bag in the community, equal to US$ 0.18/kg.

In Peru there is a large commercial market for the fruit, although the actual scale and scope of the aguaje market size remains unclear. An elaborate study of Horn et al. (2018) in 2012-2013 came to an estimate of 8,206 tonnes of fruit/year. Other studies refer to three different government statistics sources, the first ranging from 11,000 – 22,000 tonnes in the 2007-2015 period, the second reporting 61,800 tonnes/y in 2014 and 2015, and the last an increase from 41,354 ton in 2006, to 164,000 tonnes in 2017 (Nicho Pretell, 2018). Assuming a price of US$ 0.10/kg, 164,000 tons translates into US$ 16.4 million worth of fruit. The departments of Loreto and San Martin are considered the production hotspots. Export statistics (non-verified) for the 2006-2016 period vary from 13.6 - 109 million for 2006-2016 period. Table 3 shows product types and prices based on this reported data - with highest prices fetched in the US market - showing strong price increases for oils (from US$ 13.3/kg in 2006 to 27.3 US$/kg in 2016).

Table 3: Export statistics aguaje product Peru - 2006-2016 (Nicho Pretell, 2018).

Product	Value (1'000 US$)	Volume (net tonnes)	Price US$/kg (2010-2016)
Pulp	4,545	1,306.9	1.9 - 16.1
Oil	1,457	35.9	4.3 - 27.3
Capsules	1,905	71.1	2.0 - 35.1
Marmalade	24	12.0	1.0 - 10.7
Extract	72	77.1	unclear
Other	5,694	18.3	unclear
Grand sum	13,697	1,509	

Average yearly export in weight is 150 tonnes – even considering weight reduction due to processing, it is clear that most of aguaje production stays in Peru for local consumption.

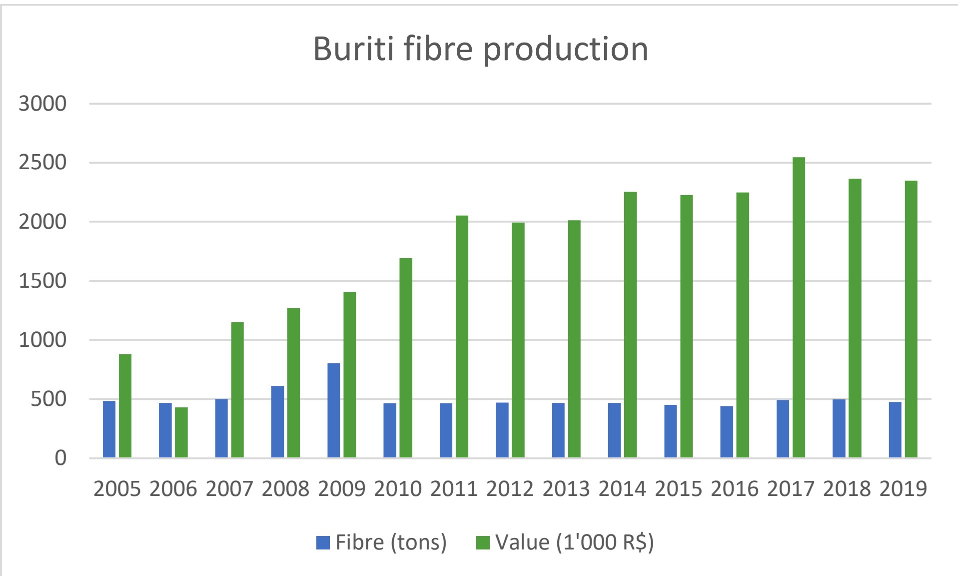
<u>Brazil value chain</u>

In Brazil, the agauje value chains for oil, (dried) fruit pulp and palm leaves are more developed, particularly in the North and Northeast. Although production in Brazil takes place in both the Amazon and Cerrado ecosystem, there is more production in the Cerrado region, likely due to the lack of more valuable alternative NTFPs like Açai, and ease of harvest. The production from smaller villages and (native) communities by *riverenos* is connected to the markets through traders, middlemen and merchants, bringing fruit and derivates such as pulp to local markets and cities (de Sousa 2018). In certain regions aguaje is considered the 'winter açai', where açai harvesters turn towards this crop outside of the major açai harvest season (July-Dec). The markets for fruit, young leaf fibres and fruit oil are growing in size and value and are expected to keep increasing each year (Virapongse et al. 2017). Even so, an interview with a Brazilian oil producing company has not seen a great increase in the oil export market in the last few years and indicated a greater market demand for various other oils and fats produced from the Amazon, like Açai oil, Andiroba oil and Murumuru butter (see also section 5.1.9 below) (pers. comm. AmazonOil).

The cosmetics industry is dominating the purchase of aguaje in Brazil, which is used for a variety of products like lotions and creams, used nationally and exported internationally. The aguaje process for cosmetics is simpler and it is possible to send it directly from the Amazon to Europe or the USA. Yet, agauje oil is not always favoured by the industry, because of the oil's dark colour. The national and international food industry is another market player, which uses the fruit for drinks, flour, candies and juices (Koolen et al. 2018).

IBGE, the Brazilian Institute of Geography and Statistics provides yearly figures on volumes and value of fibre (Figure 4). In 2019, Para accounted for 52% and Maranhão for 26% of *buriti* fibre production, with total vegetative production adding up to approximately US$ 594,000 or 1,249 US$ per ton. The officially reported prices are considerably lower than some studies indicate (8.8-66 US$/kg), this difference may be due to post-harvest added value processes such as shredding, washing, spreading, splicing, tangling and transporting, which also effects the weight and thus price per kg (Virapongse et al. 2017).

Figure 4: Fibre production in Brazil (IBGE 2021).



Only in IBGE's Agricultural census of 2006, quantities and value of both fruit pulp and fibre are reported (Table *4*: Brazilian buriti pulp and fibre production and value in 2006 (IBGE, 2021)Table *4*). The pulp production value is 7 times that of fibre, with highest production of pulp in the North and North Eastern states (
).

Table 4: Brazilian buriti pulp and fibre production and value in 2006 (IBGE, 2021)

Description	Unit	Value
Fibre (tons produced)	ton	2,345
Fibre (tons sold)	ton	1,128
Fibre (production value)	US$	347,005
Fibre (sales value)	US$	163,594
Fibre production value / ton	US$	148
Fibre sales value / ton	ton	145
Pulp (tons produced)	ton	6,450
Pulp (tons sold)	US$	2,715
Pulp (production value)	US$	2,492,627
Pulp (sales value)	US$	1,072,350
Pulp production value / ton	US$	386
Pulp sales value / ton	US$	395

The main departments where buriti pulp are produced in Brazil are Piauí (26%), Pará (23%) Maranhão (22%) and Amazonas (10%)[4].

The figure below shows a schematic overview of the value chain and prices for *Mauritia* products in Maranhão state of Brazil in 2013 (Virapongse et al. 2013). Sampaio (2012) found that a single household can produce up to 2,000 kgs of aguaje fresh pulp per harvesting season between three to five months, for which they can earn around USD 4,800 – this seems however on the high end. The social minimum price in 2021 for fruits as defined by CONAB, the state-owned enterprise trading agricultural products, was set at R$ 1.24/kg or US$ 0.23. The yield determines the cost of the fruit component in the different products (Table 5).

[4] IBGE, 2021.

Table 5: Yield of buriti fruit and value of fruit component[5]

Product	Yield	Assumed value of buriti fruit part: US$ 0.10 (value of buriti fruit part, excl. transport, labour, processing costs)	Assumed value of buriti fruit part: US$ 0.20 (value of buriti fruit part, excl. transport, labour, processing costs)
Buriti fruit	100%	US$ 0.1	US$ 0.2
Buriti flour	20%	US$ 0.5	US$ 1.0
Buriti oil	1-3%	US$ 3.3	US$ 6.6
Buriti pulp	20%	US$ 0.5	US$ 1.0

In 2015, prices for pulp in local markets of Abaetetuba were ranging from US$ 1.91-4.67, depending on the season. In the city of Belem, the reported price was 6.37 US$/kg, much higher than the village of origin (US$ 2.12), with profit margins above 100% for the trader (de Sousa 2018).

Cosmetic companies buy the raw oil as input for their products. The oil is mostly bought directly from the communities to reduce transport costs of aguaje fruit. This also reduces the chance of receiving overripe or underripe fruits, which cannot be used for oil production. Prices paid for oils for cosmetic fruits are generally higher than those paid by wholesalers and middleman, though volumes often lower (SEMA 2019).

Brazil also has a variety of cooperatives which process aguaje and sell their products to (cosmetic) companies, like Coopfrutos, Buriticoop, ANSA, Cooperative Grande Sertão (Cerratinga, 2021). Recent studies indicate price levels of US$ 13 - 22 / kg by a German trading company, with volumes at 3,600 kg/year (PDSA, 2019). In 2019, one interviewed company bought oil from the communities for R$ 60.00/kg excluding transport costs of R$ 3.00/kg. The oil was subsequently sold on the international market for R$ 140/kg excluding transportation costs. An interview with the CEO of a Belem-based Brazilian trading company that has buriti oil, scrubs, glycerinates, and extract as part of its product portfolio, made clear that in 2019, sourcing of oil from the North East (Cerrado) was done for US$ 11/kg (R$ 60/kg; excl. R$3 transport), with oil exports at US$ 28/kg (R$ 140/kg). In 2019, the company sold 2 tons, and mentioned demand was quite limited though more supply from communities was available. Another private sector contact from UEBT exported 4 tonnes of virgin buriti oil to the US at a price of US$ 29/kg in Belém.

For fibre, considering the relatively small market for fibre and products, and relatively constant production figures, we see very limited potential for SFM companies limited.

[5] Data compiled from Sampaio 2011; Brokamp 2011; Amazon Oil 2021a.

6.1.5. Estimate of potential market development and key actors

From the information gathered we see the most potential for agauje to be marketed in the international cosmetics and food (supplement) market, with oil and extracts as having most promising value chain potential.

Although local and international markets are growing in the past decade, the overall market of Aguaje is still relatively limited. In Peru, most of produced aguaje is for domestic consumption, and international export is a niche market, less developed than in Brazil.

In Brazil, the market is more developed, and generally more focussed on oil use for cosmetics, for which virgin oil is generally used. Purified or refined oil is more intended for food markets, and has a higher cost due to the further processing that is required.[6]

Although buriti oil is clearly having its niche place in such markets, it's still not a very known oil type, and further marketing on its benefits for skin and health would be required. There is clear competition with other oils, including Andiroba and Patawa and Murumuru (See Annex 3), which seem to have gained more traction in the market.

[6] Communication from UEBT.

6.1.6. Identification of (potential) off takers

Various companies and potential off takers were identified for both Peru and Brazil and can be found in Appendix I and one example is highlighted in the box below. These are mostly wholesalers and cosmetics companies that operate domestically and internationally, and some companies that use aguaje in their food products or supplements. Most of these companies also work with organic products and related certification.

AmazonOil in Brazil

AmazonOil is a company based in Belém Brazil which processes oils and butters from products of the Amazonian rainforest. The company guarantees 100% pure and natural, cold-press extraction from wild harvested products and the company produces virgin buriti/aguaje oil as part of its product portfolio. The oils produced from (Amazonian) oilseeds are used by the cosmetic, pharmaceutical, food, and textile industries in perfumes, toiletries, beauty products, as dyeing and emollient additives in textiles, as well as ingredients in foods.

AmazonOil buys buriti oil directly from the communities. Buying the fruits would significantly increase transport costs of the product and would increase chances of buying under- or overripe fruits. Pulp is also bought from surrounding communities, but only to produce products like scrub and glycerinate extracts.

AmazonOil exports products to the US, Canada and the EU. Export volumes are still relatively small, with demand of customers below available volumes from communities.

6.1.7. Presentation of available information on trade volumes and routes

Little information is available on the international trade volumes and routes of aguaje. One company we interviewed shipped 5 tonnes of aguaje oil to the US from Brazil and another 2 tonnes to Canada in recent years. Statistics from Peru show an average export volume of US$ 1.4 million (Table 3). There is also a European market for the oil and food products (supplements) as these products are found in online European shops. Yet, the exact size of any of these markets is unavailable.

6.1.8. Legal aspects

For the legal aspects of aguaje production, the regulations to produce aguaje and the rights to legally harvest the product in Peru and Brazil were investigated.

<u>Peru</u>

The Instituto Nacional de Calidad (INACAL) sets quality standards for industries in Peru. Although an aguaje standard exists, it is not used in practice (INACAL, 2020). For processing facilities there is a food safety organisation that oversees the production of aguaje food products ("personal communications" Gustavo Santos de Freitas). The legislation on the harvest of NTFPs in Peru depends on the type of land use. Harvest usually takes place in protected areas, for which a harvesting contract is needed from the authorities or in community areas. For the latter a forest use permit or *Declaración de Manejo* (DEMA) is needed, which has a map in which harvest of the product is allowed. Due to climatic changes, the location of production can change, which makes legal harvest challenging. Another legal option is harvesting aguaje in special NTFP concessions, for which recent legislation exist (CUSAF), but this is still little used. For regular forest concessions, the harvest of NTFPs should be possible, but an interview with key stakeholders indicated that this is not a practice they are aware of (pers. comm. G. Freitas, J. Ex). In doing so, the NTFP harvest will need to be included in the concession's management plan, but updating this plan is costly.

<u>Brazil</u>

For the quality of aguaje products, it was found that the rules and regulations for products used for cosmetics in Brazil are much simpler than for food products, to which stricter regulations apply (pers. comm. AmazonOil).

In Brazil NTFPs are widely exploited, but there is no clear legislative framework for the management of NTFPs. NTFPs are not defined by federal law, nor is there any federal legislation on the extraction, use, management or commercialisation of NTFPs. Also, each state can implement their own regulations on NTFPs, which has resulted in challenges to develop national policies and management plans, and to ensure sustainable harvest of NTFPs. In absence of regulations, certification is the considered the closest option for regularisation of NTFPs (Silva et al. 2020).

For the use of products which are considered a part of traditional knowledge, Brazil adopted a new legal framework on Access and Benefit Sharing (ABS), which sets the requirements for access to genetic heritage and associated traditional knowledge. Research into, or product development based on traditional knowledge on native and non-native species and their uses have to go through an electronic registration system (SisGen) to provide details on the activities and materials. This goes through a verification process after which a legal compliance certificate can be given (UEBT 2017). As aguaje is already a widely used and researched species, no difficulties with verification of the species are to be expected.

For export, UEBT indicated that there is no specific information on regulations or authorisations for the export of aguaje oil from Brazil and that the export process is fairly simple.

6.1.9. Success factors for SFM operators / The potential business case for SFM operators

When looking strictly at the value potential of a single hectare of aguaje forest, numbers are quite impressive (Table 6). Fruit value ranges from US$ 150-1,500/ha, and transforming the fruits into pulp or oil can increase the revenue value of the fruit by a factor four or two respectively (no losses in harvest/transport or transformation are assumed).

Table 6: Value potential aguaje. Based on yields from Table 1 and Table 5.
Assumed value for fruit: US$ 0.10. Assumed value for pulp: 3 US$/kg. Assumed value for oil: 15 US$/kg.

Aguaje density	kg fruit/ha	Local market value (fruit) (US$/ha)	Local market value pulp US$/kg	Local market value oil US$/kg
Low	1,500	150	900	450
Normal	3,500	350	2,100	1,050
High	7,500	750	4,500	2,250
Very high	15,000	1,500	9,000	4,500

In table 7, the revenue potential is shown of a significant forest portion of aguaje area under management as part of an SFM operation. Having 1,000 hectares of aguaje harvested annually, would lead to US$ 350,000 worth of fruit, which in itself can be transformed to US$ 1,4 million worth of pulp or US$ 700,000 worth of oil on the local market. In the international market, the oil price would roughly double. Assuming a profit margin of approximately 25%, this would lead to US$ 350,000 of profit for a 1,000 hectare operation producing fruit pulp. Connecting to international value chains and proper marketing, could in our opinion significantly increase margins, especially for oils, where trading margins are high.

Table 7: Revenue potential aguaje. Assumed is normal density (see Table 6*)*

Hectares	Ton fruit	Market value fruit (forest site) US$	Local market value pulp US$	Local market value oil US$
100	350	35,000	210,000	105,000
1,000	3,500	350,000	2,100,000	1,050,000
10,000	35,000	3,500,000	21,000,000	10,500,000

Production of the fruit itself (for further consumption or processing by third parties) by SFM companies makes little sense economically. Harvesting 1,000 hectares requires considerable investment in time, staff, equipment, training and warehousing, and is complex in terms of HR and logistics, as such an operation is labour intensive and fruits need to be processed quickly. Economically, such an operation only makes sense when the company does (or has a stake in) processing and value addition, preferably on-site or in the operations vicinity, to limit transport costs. Prices of both pulp and oil provide a solid case for value addition: US$ 1-2 million in revenues annually justifies significant investment. Currently, demand appears to be the most limiting factor here, and substantial investment in marketing & promotion is required to overcome this. Cooperating with a major off taker from the food or cosmetics industry willing to co-invest and opening up markets is thus highly recommended.

In case an SFM company decides to enter this value, there are other important barriers for SFM companies tackle. The ones we consider most important are the following:

- The fruit harvest does not lead to very significant market values, considering the level of work of harvesting e.g. 350 tons from 100 hectares, and is mostly covering labour. The value addition is in the processing to pulp and oil.
- Considerable investment in labour, staff facilities infrastructure (for storage) and processing is thus required to get to a decent business case.
- In some areas, logistics is dependent on river transport and river levels, which adds a layer of complexity to harvest of the perishable fruit. The same holds for the fact the palm tree generally grow on inundating lands, complicating harvest operations.
- Labour-intensity of harvest requires employment of large work forces in forest, while labour sometimes is scarce already.
- The type of aguaje palm could limit its use to either the food or oil/extract market.
- Aguaje harvest season may overlap with timber harvest season.
- In SFM concessions with açai, this fruit seems to be a more interesting NTFP to focus on in case açai and aguaje harvest season overlap, considering açai's high demand and established value chains.
- For international markets: competition from relatively easy-to-harvest buriti-rich Cerrado production areas in Brazil.
- Actual limited market size of aguaje, particularly in Brazil and internationally, which require further development and promotion.
- Competition for cosmetic use by Amazon-sourced oils, such as andiroba, patawa and murumuru (see Annex 3).

On the other hand, we see that the amount of aguaje-dense hectares of forest needed to come to significant volumes is relatively small compared to the typical size of an SFM concession. This would possibly allow to simply source from forests relatively nearby main concession roads and existing infrastructure. The first step for an SFM businesses to analyse the potentiality of a business case is understanding the abundance, access and type of aguaje present in the concession.

6.1.10. Sustainability, Certification and Ethics

As mentioned, the harvesting of aguaje in Peru is associated with unsustainable tree cutting. However, Horn et al. (2012) report that a handful of communities in the Peruvian Amazon are adopting sustainable strategies for the conservation and sustainable use of the species, and small-scale cultivation practices are reported (Manzi & Coomes 2009). Sustainable techniques include the introduction of tree climbing techniques to harvest the fruits without killing the palms; growing the palm in agroforestry systems and home gardens; calculating a sustainable harvest rate for palm destruction; improving land management and pest control; and testing the combination of different palm and fruit varieties. Aside from unsustainable harvesting practices, other threats to the Mauritia reported in literature include habitat destruction and fragmentation, other agricultural uses, and the decline in animal populations needed for seed dispersal (Virapongse et al. 2017).

In Peru, initiatives are being undertaken to halt deforestation of aguaje. One example is the Peru Superfruits for Forest Initiative focused on the marketing and protection of aguaje and camu camu (*Myrciaria dubia*) from the Amazon. The project works with indigenous communities to change harvest methods to conserve the trees. For fibre harvests, sustainable harvest is less of an issue as trees are generally not cut for this purpose, and harvesting of approximately 50% of leaves is sustainable.

In terms of certification, there seems to a be focus on the organic certification of aguaje product, in particular of oil. In Brazil aguaje oil is certified by companies like IMOcert and Ecocert that guarantee a low environmental impact and good social conditions. Aguaje is certified by UEBT according to the UEBT Standard. As UEBT members are predominantly beauty companies, they use virgin oil from aguaje. The supplier of the UEBT certified Aguaje is a cooperative that operates in the state of Minas Gerais in the biome of the Brazilian Cerrado. The aguaje virgin oil is sent directly to the client in São Paulo. Furthermore, some community cooperatives such as Coopfrutos (based in Acre) have been developing a certification systems for aguaje, together with the NGO SOS Amazônia, though this does not seem to have international value (SEMA 2019).

6.1.11.SWOT

The following table presents an analysis of some of the Strengths, Weaknesses, Opportunities and Threats (SWOT) of the use of aguaje by SFM operators.

Strengths	Weaknesses
• Grows easily • Abundant • Can be harvested sustainably • Already commonly used by local people. • Existing value chain in Peru and Brazil • Revenue potential through processing for cosmetic & food industries • Nutritious	• Prefers growing in wet areas in the Amazon, which makes harvest difficult. • Perishability of fruits (maximum 5 days) • At global scale and in Brazil: competition from Cerrado production areas • Lower-valued than e.g. highly demanded and priced açai. • Labour intensity of harvest
Opportunities	**Threats**
• Potential for further (international) market development, existing oil and food market for the product. • Increased interest in superfoods • Certification and sustainable harvest is both possible and already practiced, especially in Brazil. • Large number of palms on a concession area. • Aguaje can form part of a basket of palm trees to harvest from concession. • Various off takers of the product, many with a focus on sustainability. • Price levels and local market demand in Peru seem to be been increasing	• Peru: costly to include NTFPs in management plans of concessions. • Peru: continued unsustainable harvesting. • Brazil: Competition from more valuable other NTFPs, especially in the harvesting season. • Brazil: uncertainty on the growth potential of (international) market demand volume for the oil. • Main value chain is still local. • Brazil: most potential in the Cerrado region, easier to harvest the product, less competition and in particular productive with aguaje-dense areas.

6.2. Coula edulis

6.2.1. Introduction of the species

Coula edulis is a tree in the genus *Coula*, native to tropical western Africa from Sierra Leone to Angola. It is a common tree in most forest management units of Cameroon, Gabon and both Congo's.

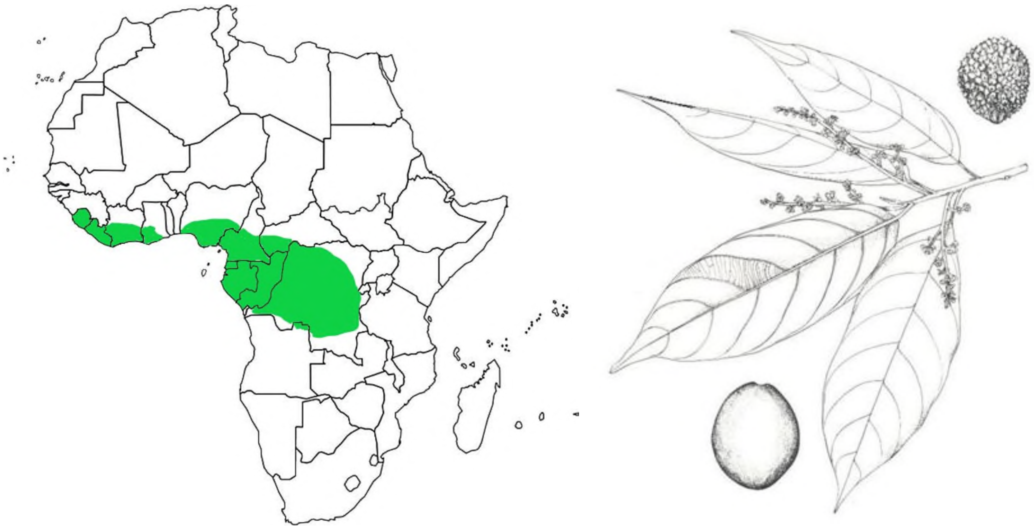


Figure 5: Geographical distribution of Coula edulis *in Africa (left), botanical drawing of* Coula edulis*. Source: http://www.liberianfaunaflora.org/liberian-flora/olacaceae/5041-coula-edulis#srcimage (right).*

Coula edulis can be found in the top canopy of forest as well as the lower story and has no special soil requirements. It is an evergreen tree growing to a height of 25–38 m, and has a dense crown that can cast deep shade. The leaves are arranged alternately, simple, 10–30 cm long and 4 cm broad, with an entire margin and an acuminate apex. The flowers are greenish yellow, with either four or five petals.

Fruiting and flowering depend on the area within the range. In Gabon fruiting was reported from January to April (Moupela et al. 2014a) while a report from Côte d'Ivoire indicate December to April (Moupela et al. 2014b). The fruits are 3–4 cm long, with flesh surrounding the kernel, 5–6 mm thick, smooth in texture and can be red or green. Fruiting is annual and Moupela et al. (2014b) found that minimum tree diameter for flowering was 10.6 cm while the diameter for regular fructification was 23 cm. The wood is very durable (in certain aspects comparable with azobé (*Lophira alata*)). The timber is yellowish with darker stripes and sometimes marketed as tigerwood. The timber is not generally harvested in Gabon and Cameroon.

Coula edulis is a nut that is appreciated for its taste and texture. In the range where the species is present the nuts are collected and consumed in high numbers when it is in season. The nuts are cracked and eaten raw or roasted as a popular snack (Mikolo Yobo et al. 2020). The nut yields a yellowish oil.

The nut contains 34.9% of fat (95.5-97.4% oleic acid) and 38.6% of starch, while the raw flour contains 33.9% and 44.1% respectively and 604 mg/100 g of potassium and 393 mg/100 g of phosphorus. In a test where the oil was stored under tropical conditions it showed significant deterioration during the 90 day test period (Ekissi et al., 2016). The nut oil is traditionally used as a culinary oil. The fact that the oil is over 90% oleic acid means it is well-suited for use as a high-end salad oil. Oleic acid is a monounsaturated fatty acid and is widely associated with reductions in LDL cholesterol and blood pressure levels. It is found at 75% in olive oil. The US FDA has approved a health claim on reduced risk of coronary heart disease from high oleic (>70%) oils, spurring a rush to create high oleic vegetable oils from soybean, canola, safflower and sunflower. As Coula nut oil is higher in oleic acid than even a highly modified High-Oleic Sunflower Oil (typically in the range of 70-80%), it appears to be a very interesting candidate for commercial development as a niche culinary oil. It may possibly deserve the moniker of being "the highest natural source of oleic acid in the world".

Coula edulis is a locally well-known NTFP, which is collected by people living close to the forest when it is in season. It is mostly used for direct consumption, but quantities are also taken to city centres for sale (Moupela et al. 2014).

6.2.2. Resources availability and sustainability

In a forest in south Cameroon the are about 1,5 trees of the fruiting size (DBH of >20 cm) per hectare (Form International data), making this a common tree species. The population diagram shows plenty of younger trees and gradually decreasing numbers per diameter class. Doucet et al. (1996) found a similar population structure but higher densities in a 10 hectare forest in Gabon, where over 4 trees per hectare were found a DBH of >30 cm. Ngobo et al. (2003) report 15 to 27 fruiting trees in a 4.7 hectare research site. The number varies per year, indicating that not all trees fruit every year. It is reported that about 40% of the trees fruit (Moupela et al. 2014b).

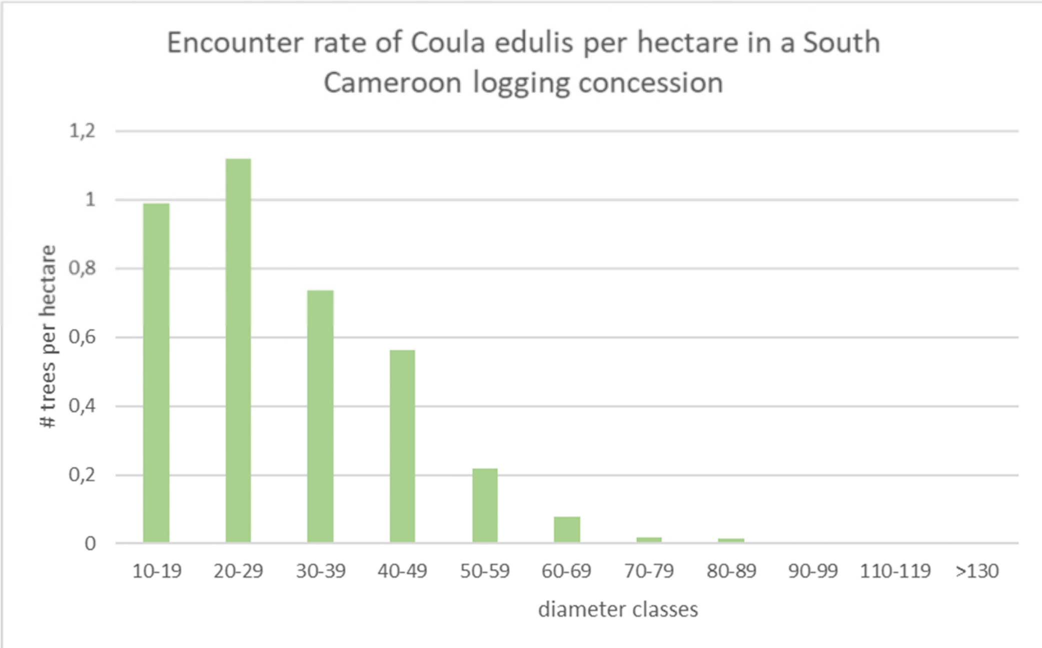


Figure 6: Population histogram of Coula edulis *in a concession in South Cameroon.*

6.2.3. Characteristics of harvest and the value chain

Moupela et al. (2014a) have studied the collection and subsequent commercialisation of Coula edulis in Gabon. They found that it takes a person five hours to collect, bring home and crack 45 kilograms of fruits. The result is nine kilos of cleaned nuts. When sold locally one kilogram of cleaned Coula nuts is worth about USD 1.17 on village markets and twice that in the city markets. Iponga et al (2018) showed that households derive little cash income from the sale of Coula nuts, but that the value of sale and consumption combined represents about 30,000 FCFA (USD 52.65) of which over 80% is auto-consumed. A study by Angoni (2015) revealed that the quantity of nuts brought to a market in Cameroon was between 100 kg and 200 kg depending of the time of year.

Table 8: Data from literature that allow the making of calculations and estimates

Item / activity	Quantity	Price	reference
Trees per hectare	1-4 trees per hectare		Data from Form International
Collection and cleaning	45 kg of fruits/9 kg of cleaned nuts	USD 10.5 in village USD 21 in town	Moupela et al. 2014a
Reported quantities	3,353 kg fruits / 534 kg nuts		Moupela et al., 2014a
Sales costs (transport and tax)		USD 2.34 per 20 kg bag of nuts	Moupela et al. 2014a
Nut quantity at market	100-200		Angoni 2015
Production per tree	20-100 kg (average 36-42 kg/tree)		Moupela et al. 2014b
Part of population fruiting	40%		Moupela et al. 2014b

Potential production of *Coula edulis* fruits depends on the density found in the forest. The density varies between 1.5 to 4 trees per hectare that are of fruiting age. Considering that not all trees fruit (about 40% does) this means an annual expected production of between 21.6 and 67.2 kilograms of fruits per hectare. If we take the average of these figures we can say that the mean potential yield of *Coula edulis* is 44.4 kilograms per hectare. Getting the 45 kilo of fruits (giving the nine kilos of cleaned nuts indicated to be achievable in five hours work) then involves collecting all nuts from about one hectares. As it is unlikely that a tree drops all its nuts at once, in reality a larger area will have to be searched several times.

From a community forest in Cameroon or Gabon (typically 2,500 hectares) the maximum yield is then about 22.2 tonnes. At village level this could earn about USD 25,970 in Gabon, probably much less in Cameroon and other countries where price levels are lower. The same amount brought to a city market in Gabon will generate a profit of USD 51,950 - (USD 25,970 + USD 2,597 tax and transport)) = USD 23,383. If all nuts were collected from a 300,000 hectare forest concession the sums would amount to 2,640 tonnes earning about USD 6.18 million if brought to the city market and if that market could adsorb the production.

It is not likely that all nuts produced can be brought out of the forest. The produce from trees close to villages and roads will be completely collected, but if the effort of collecting it is too high (or the price considered too low) trees further afield will not be visited. At village level only about 20% of the nuts are sold which suggests that the price received is considered low. It is better to eat it then to sell it. If 80% of the produce is consumed locally, this means that available volume is again considerably lower.

Comparing the prices obtained in villages with prices for cashew in other areas, we see that a kilo of raw cashew nut (unpeeled, unprocessed) costs about USD 3.08/kg FOB in Ghana in June 2020 (https://www.comcashew.org/news?archiv=2020). The farm gate price was reported to be USD 0.65 per kg. This farm gate price would be a good benchmark for Coula nuts of which the flesh is removed but which have not been cracked. Discussions with nut traders have revealed that for food security reasons, there would be an interest to buy the unprocessed fruit at village level. The removal of the fleshy pulp can then be done under controlled circumstances and the cracking of the shells can be done closer to the market, again under controlled circumstances.

The price of processed cashew nuts is around USD 4.68 per kg. We can also keep this as a benchmark for Coula. Through its story of being a novelty health food, it may fetch even more. The Coula nuts are semi processed when obtained in the villages. The shell has been removed, but they are not thoroughly dried and graded. The case presents itself as quite positive however. There is some room to accommodate the cost of a village price increase, grading and further processing and shipping.

Table 9: Overview of the potential of Coula edulis

Hectares	Ton nuts	Market value unprocessed nut (forest site) US$	Market value processed nut (US / EU) US$
100	0,44	250	1,760
1,000	4,4	2,500	17,600
10,000	44	25,000	176,000

With this scenario in mind, the price paid at village level can be lower. Removal of the fruit pulp could be done with a tumbling drum as is also used to take the fleshy part of walnuts (*Juglans regia*). It requires some research to determine how long the fruits can be stored without having a negative effect on the nut quality. Nut with the flesh removed can be sun-dried and stored until collection. The price will in this case be lower than the price for cleaned nuts, but less labour has also gone into them.

In terms of grading checks and chemical checks for nuts in international trade, the key requirements are a) acceptable levels of pesticide residues, b) acceptable microbial loads and c) absence of aflatoxins. None of these are anticipated to be a particular challenge for Coula nuts. Pesticide residues are managed through implementing organic standards that minimise the risk of contamination, As the tree is naturally occurring (rather than cultivated) and is found in moist tropical forests where pesticide use is essentially non-existent, the main risks are likely to occur at the point of storage (if e.g. nuts are stored at a collector's home under a roof that has been sprayed with anti-malarial insecticide). This is specifically addressed under organic certification and is not therefore likely to be a major threat. Microbial loads and aflatoxins are also directly associated with the storage and handling. As Coula nuts are found in a generally humid environment, there is a risk associated with this, but the risk should be seen as manageable.

6.2.4. Estimate of potential and actual market size

Coula edulis is currently traded in the national markets of the countries where it is produced. It is difficult to estimate market size. Information from Angoni (2015) suggests that in a small town such as Edea in Cameroon, weekly supply to the market is between 100 and 200 kg weekly during the season. The produce offered for sale is mostly collected near to the market town. It is difficult to extrapolate this information to a larger scale. No more information on quantities brought to market for this commodity was found. Literature shows that auto-consumption is high, and that only a small portion of the produce is actually sold in town markets. *Coula edulis* is not currently traded in the international market, so no information is available on current trade. The potential is enormous however, from FSC concessions in the Congo basin alone, which could have as many as 5 to 20 million productive *Coula edulis* trees in total a potential volume of 44,400 tons of cleaned nuts with a potential value of around US$ 45,000,000.

6.2.5. Identification of (potential) off takers

For the purpose of this study we have spoken with people form a nut trading company "Red River Foods", who were not familiar with the *Coula edulis*. The story of the nut is good however, and they would like to see if it has what it takes to make it a success in the market. To sample the market they would need an initial lot of about 30 kg of cleaned material. Also they would have to see that parties are willing to collect the nuts and bring them together in considerable volume.

Red River Foods
Red River Foods is a leading global supplier of nuts, seeds, dried fruit, and specialty snacks. Every day we live our mission of sourcing the highest quality foods, providing expert market insight, and developing sustainable supply chains around the world (https://redriverfoods.net/).

Africa is the origin of numerous Red River products including cashews, macadamias, and dried fruit. West Africa has become a burgeoning source of raw cashew nuts, quickly challenging India, who until quite recently, was the largest producer of raw cashew nuts. Both produce an average of 1.5 million metric tons of cashews annually with West Africa's numbers growing exponentially each year. In addition to our dedicated teams on the ground, most notably in Ghana and Ivory Coast, we oversee sustainability programs that improve not only the harvest but the health, safety and welfare of those who depend on sourcing our products for their livelihood.

Africa is also a source for our dried fruit including mango, pineapple, and papaya. We are working with fruit processors to increase their organic sourcing capacities as there is great potential for the growth of organic fruit. Red River Foods has a home office in Richmond, Va., and has offices in New York, Seattle, and California. The Seattle office manages the pine nut and pepita operations through Golden Pacific Foods, a subsidiary in Dalian, China. Red Ricer Foods has a processing factory in Malatya, Turkey and factories in China and Vietnam.

6.2.6. Success factors for SFM operators

Minimum wage in the forestry sector in Gabon is reported to be 150,000 FCFA per month which is USD 269. In all other countries in the sub region it is considerably less (37,000 FCFA/month or USD 65 in Cameroon for instance). With 25 working days in a month this corresponds to USD 10.76 – USD 2.57 per day. Of course this amount is without the taxes and other employer costs paid. So in reality the cost of a labour force is higher. It is possible that a paid worker will harvest and crack a similar amount of fruits as reported in the study by Moupela et al. (2014a). But the cracking is not needed at it increases the risk of contamination of the nuts. This means that hired labour will result in a similar cost price as for purchase in a village. In neighbouring countries were salaries are somewhat lower, the resulting price for the raw product will be lower.

Allowing for start-up time such as arriving at the road side of an area where to collect and walking into the forest, it is reasonable to expect that a worker can't go deeper into the forest than an hour's walk. If we estimate this to be four kilometres, this means that a strip of four kilometres on either side of the road can be accessed for collection. Per kilometre of road an area of 800 hectares can be accessed, potentially yielding around seven tons of cleaned nuts.

EU Novel Food regulation

Novel Food is defined as food that had not been consumed to a significant degree by humans in the EU before 15 May 1997, when the first Regulation on novel food came into force.

'Novel Food' can be newly developed, innovative food, food produced using new technologies and production processes, as well as food which is or has been traditionally eaten outside of the EU.

Examples of Novel Food include new sources of vitamin K (menaquinone) or extracts from existing food (Antarctic Krill oil rich in phospholipids from Euphausia superba), agricultural products from third countries (chia seeds, noni fruit juice), or food derived from new production processes (UV-treated food (milk, bread, mushrooms and yeast).

The underlying principles underpinning Novel Food in the European Union are that Novel Foods must be:

- Safe for consumers
- Properly labelled, so as not to mislead consumers
- If novel food is intended to replace another food, it must not differ in a way that the consumption of the Novel Food would be nutritionally disadvantageous for the consumer.

Pre-market authorisation of Novel Foods on the basis of an evaluation in line with the above principles is necessary.

To be able to trade in such material a company will have to obtain a license form the director of forestry. The drying and conditioning of the product will require a clean work space where the climate can be controlled (to avoid humidity). Transport from the road side to this work space will be needed (also for personnel). Then when the product is ready for export it needs to be transported to the point of loading. Before loading there are several taxes to be paid. It is possible that similar systems as for cashew and cocoa can be employed. The cost of conditioning and packing is then relatively modest and may be around USD 1.17 a kilo.

6.2.7. Organisation model for the forest managers.

With the prices obtainable it is possible to hire people to do the collecting. Hoping to buy nuts in villages is likely less successful as local consumption is high, and prices would have to be interesting enough to persuade people to forgo their own consumption in favour of cash earnings. Calculations how that paying people to collect and crack the nuts leads to a price which is more or less the same as the current village sales price (at low volumes). So offering more in order to avoid having personnel do the collection would lead to higher purchase prices.

6.2.8. Legal aspects

In the forest legislation of Cameroon the use of the nuts is granted to the people living close to the forest (droit coutumier). In Gabon in decree n° 692/PR/MEFEPEPN of the 24th of August 2004 defines the products that can be collected by the local population as part of their customary rights. Decree 1029/PR/MEFEPEPN of 2004 indicates that for commercial collection of NTFPs such as Coula nuts, a permit is to be obtained at the director general of the forestry department. The request for this permit needs to include clear description of the way the product is to be collected and in which forest area. It also needs to be specified where the product it to be sold.

The first hurdle towards commercialising the oil as a culinary oil will be EU Novel Foods approval. Neither the oil nor the nut have been evaluated for compliance and will therefore require preparation and submission of a Novel Foods dossier for approval. Although this process is now relatively straightforward under the revised regulations for traditional foods, it will nevertheless take time and resources to achieve. On the positive side, there are no known toxicological issues that are likely to hinder approval.

It would also be worth investigating the potential use of the nut oil as a cosmetic ingredient. The advantages of this are that the regulatory hurdles are lower for cosmetics than for food oil. High oleic acid oils are used in skincare to repair dry and damaged skin. The rich oily feel of oleic acid means it is a good moisturiser that adds body and texture to a cosmetic product. Its high oxidative stability also helps to prolong the shelf life of the product. It has known anti-inflammatory and healing properties and is associated with free radical scavenging. Marula oil is another high oleic acid (around 78%) oil used in skincare that has achieved considerable success in recent years in the cosmetics markets. Again, the fact that Coula nut oil is so exceptionally high in oleic acid suggests a niche could be found for it.

6.2.9. Business case for Coula edulis (sale to Red River Foods)

Table 10: Relevant financial sources and sinks in the production of *Coula edulis* at a concession level.

Description of cost item	units	unit cost (USD)	total cost (USD)	remark
Collection 45 kg. of nuts in forest and removal of skins	6 hours	0.087	3.93	Based on Cameroon minimum wage with 50% charges applied, count 6 working hours/day
Price per kg nuts with shell	18	0.22	3.93	weight after cleaning 18 kg
Collection of nuts in villages	day	234	234	volume collected estimated at 2,000 kg per day including vehicle charges
Collection cost	2,000	0.12	234	2 tons collected
Warehousing costs during three months	3	1,170	3,510	
Volume kept in warehouse (10 tons)	10,000	0.41	3,510	
Shipping to US including charges	10,000	0.41	4,095	
Farm gate price (cashew benchmark)		0.65		
Profit at farm gate (collected by SFM company)		0.32		
Total price per kg FOB		1.09		
If a concession can yield approximately 50 tons, farm gate profit is potentially		15,990		

From the estimate it becomes apparent that collection by the SFM company can generate a net income of USD 15,990 for 50 tons. If the collection is left to the buyer, people in the villages can earn USD 0.65 (farm gate price), which corresponds to payment of a minimum wage (Cameroon) including charges. The actual figures sound modest, but the work involved is mainly a matter of organisation. The total income generated depends on actual volume available in the forest. It seems this product provides companies with a good opportunity to have corporate social responsibility (CSR) activities that are positive for the communities as well as the company.

6.2.10. Sustainability, Certification and Ethics

Areas reserved for villages are off limits, and this needs to be carefully checked. Also other holders of customary rights need to be consulted prior to collecting, as it infringes directly on their right to collect. Collecting can only be done after prior informed consent and the signing of a benefit sharing agreement. When collecting the needs of local wildlife also need to be taken into account. Food sources such as Coula nuts are important to the larger fauna such as apes and elephants.

Parties buying the nuts for the international market will present certain requirements such as the avoidance of child labour, the assurance of product cleanliness, the legality of the harvest.

6.2.11.SWOT

Strengths	Weaknesses
• Common species • Easy to collect • Good taste • Oil can be stored well • High oleic acid content is a unique property	• Seasonal • Not known in the international market • No existing export network • Local consumption is preferred over sale • harvesting is labour intensive • competition with fauna • In principle the rights to harvest are with the local population • Production area does not really produce other nuts. • It is not clear if the market is ready for a new nut
Opportunities	**Threats**
• Pealed nuts can be available at a relatively low price an in potentially decent quantities • Production area does not really produce other nuts and few other agricultural commodities • Good story potential • The production of the nut can be a contribution to preservation of the forest	• The product is currently unknown internationally • Enthusiastic collection may put pressure on natural regeneration • The timbers suitability for attractive flooring (tiger wood) may become a competing use of the tree if other timbers become scarce. • The frequent damp conditions in the production area make conditioning a challenge.

6.3. Dammar gum

6.3.1. Introduction of the species

Dammar gum is a resin extruded from the tree family *Dipterocarpacea*, a family of 16 genera and about 695 known species of mainly tropical lowland rainforest trees. The largest genera are *Shorea* (196 species), *Hopea* (104 species), *Dipterocarpus* (70 species), and *Vatica* (65 species) (Christenhusz and Byng 2016). Many are large forest-emergent species, typically reaching heights of 40–70 m. The trees that yield dammar are commonly found throughout South-East Asia and are also a major source of timber. *Agathis dammara* (*Araucariaceae*) also produces dammar gum, although it is taxonomically far removed from the Dipterocarps and the substance is actually a resin.

The main Malayan dammar varieties are Damar Mata Kuching from *Hopea micrantha*, Damar Temak from *Shorea hypochra*, and Damar Penak from *Neobalanocarpus heimii*. Resin is usually produced by wounding the tree by means of incisions, although some of it is gathered in fossilized form. Resin production varies from tree to tree, ranging from a few kilograms to twenty to thirty kilograms per year per tree (Heyne 1950).

Dammar gum is a triterpenoid resin, containing many triterpenoids and their oxidation products. Their main use is as an incense, and in the manufacturing of varnishes, lacquers and paints. Consumption of paints and varnishes has declined over the years due to the widespread use of synthetic materials. Nowadays, dammar is still used in varnishes for some fine arts. Dammar varnish and similar gum varnishes auto-oxidize and yellow over a relatively short time regardless of storage method (Dietemann et al. 1982). Moreover, the water-resistant and glazing properties of dammar, alongside its edibility, make it a multi-purpose ingredient in various other applications. Outside Europe, Damar is used as a food additive, functioning as a shiny protective external coating. The beverages industry also uses it as a clouding agent to make drinks appear more natural and appealing. Dammar dissolved in a solution of xylene or chloroform is used to mount and preserve thinly sliced biological sections for examination under the microscope. Additionally, it is used as a water-resistant coating around pharmaceutical tablets. Dammar is also used in the batik technique of wax-resistant dyeing. The printing industry uses dammar in coloured printing inks, and it can be coated onto beeswax cloth to make beeswax food wraps. Lastly, it is used in the manufacturing of shoe polishes, typewriter ribbon, carbon paper and in plastering for walls and roofs.

6.3.2. Resource availability and sustainability

Due to the many uses of dammar-producing trees, including timber, many species are endangered today as a result of overcutting, extensive illegal logging, and habitat conversion. 490 species are included on the IUCN Red List and an astonishing 265 of those are categorized as endangered or critically endangered (iucnredlist.org). This includes the three main Malayan dammar sources. Research indicates that widespread degradation of land and forests also threaten the sustainability of dammar (Anasis and Sari 2015; Gilbert 2017). In the Pesisir Barat Province (Indonesia) many people have sold their forested land or converted to seasonal plantations the last 15 years. One of the main reasons is the low and decreasing dammar gum prices (Wollenberg et al. 2001; Gilbert 2017). The switch to commodities that are more economically promising, including timber, will further threaten dammar gum producing trees.

Yet, forest management practices developed by local people have been efficient in fulfilling basic household needs and being able to guarantee the sustainable use of natural resources for over a century (Murniati et al. 2001; Kusters et al., 2007). Dammar is often harvested by smallholders in an agroforestry context, a system which maintains a high level of biodiversity and ecological functions (Michon et al. 1987). This system provides long-term sustainable productivity through maintaining soil and water quality, carbon sequestration and biodiversity (Nyhus and Tilson 2004; Mutuo et al. 2005). From an economic perspective, the agroforestry system provides a wide range of income sources to rural and urban households and the actors along the dammar gum trading chain (Bouamrane 1996). In- or outside of an agroforestry context, resin production can promote the conservation the trees in question by increasing their standing value. Still, resin collection is only sustainable when conducted properly. Over-tapping can lead to growth suspensions and tree mortality.

Figure 7: In the forests near the southern Sumatran village of Krui, 48-year-old Marhana climbs up the trees to harvest dammar. (Adapted from Simon, Julia (19 October 2019). "Could This Tree Be an Eco-Friendly Way to Wean Indonesian Farmers Off Palm Oil?". All Things Considered.

6.3.3. Characteristics of harvest and value chain

Dammar trees can be tapped from the age of 20, or when they have reached ~25 cm in diameter. Dammar resin can be harvested two to four weeks after incisions are made. Usually, it is scraped out of the holes with an axe hammer. It is thereafter stored in special barrels and carried to a collection point or warehouse. Old tapping wounds can be re-used, and if they are up high, tappers will reach them with simple climbing gear as shown in Figure 6.

A few hundred species produce dammar resin, of which the resin of only few species is exported to the west. Varghese and Ticktin (2008) report that the loss of tree tenure in some areas has led to a higher frequency of tapping and to the production of lower quality, lower value resin. Factors driving changes in both tenure and tapping strategies include rising commercial demand and value, pressure from outside harvesters, changes in livelihood strategies, and habitat destruction.

The promotion of tapping and sale of only high-grade resin is a good strategy to promote sustainable harvest practices. This can be aided by enrichment planting to help address the underlying causes of overharvest and allow for the sparing of trees for increased reproduction (Varghese and Ticktin 2008).

6.3.4. Estimate of potential and actual market size and key actors

The wide array of applications of dammar gum is driving global dammar gum market growth. Novelty applications of dammar gum include its use as a glazing or clouding agent in the food industry, as well as its use in beeswax food wraps. According to global dammar gum market analysis, Asia Pacific held a significant market share in the global market and is expected to grow rapidly. Major dammar gum producing economies include India, Vietnam, Indonesia, Thailand, Laos, and Cambodia. Moreover, agroforests of dammar trees are developed in Sumatra, Indonesia, to cater for the growing demand.

According to Indian Institute of Natural Resins and Gums, annual production of gum dammar batu in India was 80-100 tons in 2014-2015. Furthermore, India imports dammar from Indonesia, Thailand, Vietnam, and Lao. During 2014 and 2015, more than 95% of dammar resin in India was supplied from Indonesia and Thailand. 54.54% or 9,916.49 tons of the total imports of dammar resin was imported from Indonesia and 43.91% or 3,593.35 tons was imported from Thailand. India imported 13,663.31 tons of dammar resin in between 2014 and 2015 of which less than 1% was exported to Jordan, Vietnam, Germany, Maldives and Sri Lanka. According to Coherent Market Insights study, around 60% of dammar gum was used by the incense industry in India in 2016. India is one of the largest manufacturer and exporter of incense sticks, thereby fuelling growth of the market.

The U.S. held a significant market share in the North American dammar gum market in 2017, owing to a high demand for dammar gum in the food and paint industry.

6.3.5. Identification of (potential) off takers

Key players operating in the global dammar gum market include Nexira Inc., Sennelier, Cornelissen & Son, William Bernstein Company, Spectrum Chemical Mfg. Corporation, PT. Samiraschem Indonesia, and Bandish Enterprises. The global dammar gum market is segmented by end-use in various industries: food and beverage, paint/varnish and (textile) printing, cosmetics, incense, pharmaceuticals and packaging. Moreover, it is segmented by region.

6.3.6. Presentation of available information on trade volumes and routes

Information on trade routes for dammar resin is scarce. A study on the dammar market in Indonesia established the domestic network from farmers to exporters and domestic companies (Figure 8) (Nur'aini et al. 2020).

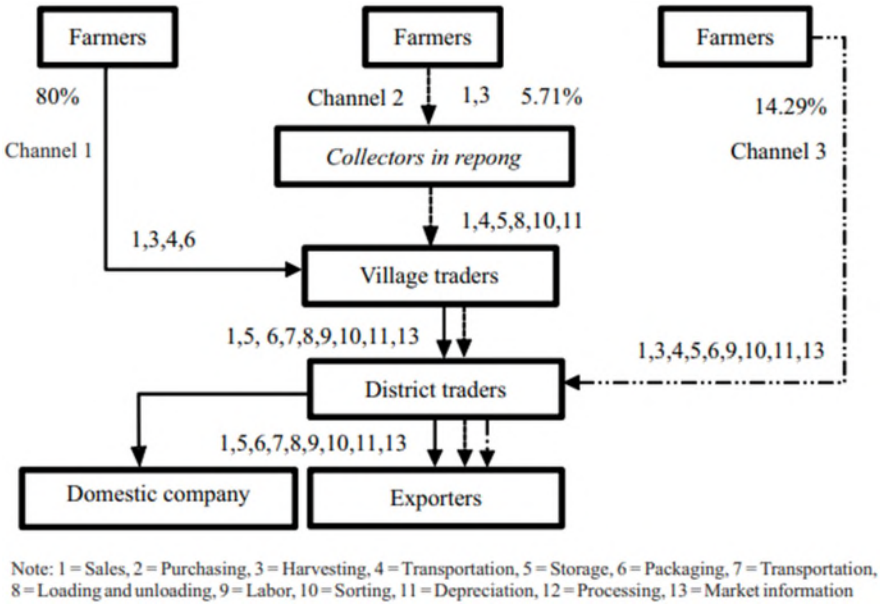


Figure 8: Trading system of dammar gum in Pesisir Barat Lampung, Indonesia.

This is only a case study for a specific dammar species in Pesisir Barat Lampung in Indonesia. Trade routes concerning other species and regions may differ.

6.3.7. Available information on prices/ qualities

Resin particles are sorted by size, pellucidity and degree of contamination (Torquebiau 1984). The most pure and clear batches of dammar are sold as "damar mata kucing" ("cat eye"). This resin type can only be obtained from tree tapping. There are approximately 40 species that can produce this resin. The local price of cat's eye resin in Indonesia is IDR 75,000 (USD 5.22) per kg (Hasbie Hasbillah, pers. comm.). Black resin or copal resin is the next dammar gum grade. This specific resin is harvested from *Agathis dammara* and is yellow and soft. It is used locally as a lacquer and varnish. Local prices start at IDR 14,000 (USD 0.97) per kg (Hasbie Hasbillah, pers. comm.). The cheapest grade of dammar gum is stone resin, named after its rock-like appearance, which is fossilized resin. This too is used for producing paint and varnish and prices in Indonesia start at IDR 11,000 (USD 0.76) per kg (Hasbie Hasbillah, pers. comm.).

Resins for use in varnishes can be easily obtained from European web shops (e.g. kremer-pigmente.com, labshop.nl, vanbeekart.nl), where prices vary between USD 11.7 and USD 37.4 per kg of resin. Relying on the pictures provided on these web shops, this concerns cat eye grade dammar gum.

6.3.8. Potential revenue Dammar gum

Dammar gum can provide an additional revenue stream for forest owners. Potential revenue is subject to various factors concerning quality of dammar resin, presence of suitable *Dipterocarpaceae* species, distribution of DBH in the forest stand and availability of sales channels.

Table 11: Price data necessary for the calculation of the dammar gum business case for forest owners.

Data	Quantity	Cat eye resin	Stone resin	Agathis resin	Average
Harvest potential per tree	kg	17.5			
Price per quality Damar	USD/kg	5.22	0.76	0.97	2.32
>30cm dbh trees per ha	trees	60	60	60	60
Potential revenue 100% suitable species	USD/ha	5,479.0	798.5	1,019.7	2,432.4
Potential revenue 20% suitable species	USD/ha	745.3	160.3	203.6	707.2
Potential revenue 1% suitable species	USD/ha	55	8.2	10.5	24.6

The calculations show an ideal distribution of suitable species. The revenue figures are limited to the mix of species of *Dipterocarpaceae* in the forest stand. The prices are based at farm gate. Actual revenue per hectare will depend heavily on species distribution. A 20,000 hectare concession could potentially produce USD 9,734,400 in resin with a 20% suitable mixed species cover, while that would be USD 491,400 with 1% species coverage. A lower percentage of suitable trees is assumed to be realistic in a sustainable logging concession context. Dipterocarps will also be harvested for timber, and pressure on the forest should not exceed sustainable levels.

In Indonesia, the living wage in 2018 was around IDR 1,400,000 (USD 98). Assuming that a full-time employee (with a five-day workweek) can collect from 25 trees per day, and the 20,000-hectare forest contains 1% suitable species, 96 working months are needed to collect all available resin. Total wage costs are then IDR 134.4 million, or USD 9,385. Thus, assuming USD 1.17 in transportation and storage costs per kg resin at USD 238,680, a positive picture emerges for dammar collection, even with only 0.6 suitable trees per hectare.
In Malaysia the living wage is much higher at approximately MR 1,800 (USD 429.85) per months. Wage costs then increase to USD 48,280.34. Still, assuming the same storage and transportation costs, dammar resin collection could be a viable business venture.

Table 12: Potential of damar tapping for concession areas.

Hectares	Ton resin	Market value high quality (forest site) US$	Market value low quality (forest site) US$
100	2,1	11,000	1,600
1,000	210	110,000	16,000
10,000	2,100	1,100,000	160,000

6.3.9. Success factors for SFM operators

Many of the areas where NTFPs are collected are also home to different indigenous communities whose livelihoods are often intricately linked with NTFPs. In case of dammar production, collaborations with local people for resin collection can provide concession holders with indigenous and local knowledge, as well as lead to increased local livelihoods.

Moreover, there is no timeframe connected to dammar harvesting, although the monsoon season will certainly not be optimal. This provides concession managers with various options regarding collection times and intensity.

As mentioned earlier, most Dipterocarps are prized timber species. As such, concession holders could experience interference between species used for timber and species used for dammar production. Revenues will be maximized if trees for resin production are chosen based on resin grade and amount produced (which can differ between species and diameter classes).

6.3.10. Legal aspects

The list of NTFPs permitted to be harvested is often stipulated by the state forest departments, retaining rights to harvest and trade NTFPs for indigenous communities only. Sometimes no-collection zones are indicated. In Indonesia, NTFP legislation has become more community-focussed in recent years, in order to improve equity in the sector. NTFPs in protected areas can only be collected by local people. A permit is needed to collect these NTFPs, and only some types of NTFPs can be collected there, which do not include dammar resin. NTFPs collection in production forests is allowed but needs to benefit local communities and is subject to CITES regulation. NTFP collection in this landscape cannot exceed 20 tonnes per household, but it is unclear if the same limits apply to industrial enterprises (De Rozaria 2020).

In Europe, dammar does not have an E-number, and is thus not authorised as a food additive. However, it is authorised for use in food contact surfaces [Commission Regulation EU

10/2011]. In the US, dammar "may be safely used as the food-contact surface of articles intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding food" [FDA CFR 21 175.300].

In October 2017, Flavor and Extract Manufacturers Association of the United States (FEMA) published GRAS 28, which recognized purified dammar gum as GRAS (Generally Recognized as Safe) for use as flavour adjuvant in food. The U.S. Food and Drug Administration approved use of dammar in adhesives and components of coatings for indirect food additives in its Code of Federal Regulation. The regulation approves use of resinous and polymeric coatings including dammar as food contact surfaces.

6.3.11. Sustainability, Certification and Ethics

Given the fact that dammar gum can be an important produce for local livelihoods in South-East Asia, it is important to make sure that large-scale harvesting is done ethically and in collaboration and in consultation with local communities. Within the right system, concession holders and local communities can both benefit. This could be substantiated through sustainable and ethical sourcing certification, which is not yet implemented for dammar gum and could provide a market advantage.

6.3.12. SWOT

Strengths	Weaknesses
• Multitude of applications, including novelty products such as food wraps and pharmaceuticals • Can be harvested all year round • Community-based NTFP harvesting is in line with recent policy developments in Indonesia	• The market for varnishes and lacquers is no longer growing • Some species that produce dammar will also be target timber species, posing a conflict in logging concessions
Opportunities	**Threats**
• Can aid in conservation of endangered Dipterocarps through increasing the standing-value, which can be certified and/or marketed • Can create significant community benefits, which can be certified and/or marketed • Can be a profitable venture in a concession context	• Market increases for non-paint/lacquer/varnish applications depends (amongst others) on food and health regulations in the global North, and may not actually happen

6.4. Irvingia spp./Bush mango

6.4.1. Introduction of the species

Irvingia (Irvingiacaeae) is a small genus of rainforest trees from Africa and South-East Asia encompassing 7 species (WCSP 2021). Its best-known member, *Irvingia gabonensis*, is native to the lowland rainforests of Central and Western Africa and grows up to 40 meters tall. It produces large, mango-like fruits that are used in a myriad of ways by local communities in Central and Western Africa. The main use of the fruit, commonly known as bush mango or African mango, are the seed kernels (also known as dika nuts), which can be used as a condiment and to thicken soups and sauces. To a lesser extent, oil is harvested from the seeds which can be used for cooking and cosmetics. This oil may have potential as an alternative to palm oil due to the similar make-up. Moreover, the fruit is sweet and edible and the pulp can be used to make a black textile dye. *I. gabonensis* has also been used as a medicinal plant to treat various ailments including diarrhoea, pain, yellow fever, hernia and against poisoning. Lastly, the wood of the bush mango, named 'andok', can be used for construction, appliances and fuelwood (Zapfack et al. 2001).

I. gabonensis is morphologically almost identical to another member of the *Irvingia* genus: *Irvingia tenuinucleata* (synonym of *Irvingia wombolu* and commonly called so in publications). Their similarities also extend to their use as an NTFP. The most striking difference is the variation in pulp taste. The pulp of *I. gabonensis* is sweet and therefore used in jams, juice and wine. *I. tenuinucleata* on the other hand has bitter fruit pulp which is not eaten (Elah et al. 2009).

Outside of Africa, *Irvingia* spp. is mostly used as a dietary supplement due to its potential as a weight-loss stimulant and its potential to improve metabolic parameters such as blood-glucose levels and LDL cholesterol levels (Ngondi et al., 2005; Ngondi et al., 2009; Azantsa et al., 2015; Méndez-Del Villar et al., 2018).

6.4.2. Resource availability and sustainability

Both *I. gabonensis* and *I. tenuinucleata* occur in Central and Western Africa from Uganda to Ghana and possibly all the way to Sierra Leone (Ainge & Brown, 2004). Apart from their occurrence in the wild, bush mango trees are also widely nurtured and cultivated in home gardens, on farm land and in agroforestry systems within their range (Vihotegbé et al., 2012; Ofundem et al., 2017; Nfornkah et al,. 2018). In the Dahomey Gap, *I. gabonensis* is the most intensively cultivated tree (Vihotegbé et al., 2012). Despite the origin of these fruits not always being forest land, that are still considered an NTFP (Ingram et al., 2009).

Although there are far-reaching similarities between *I. gabonensis* and *I. tenuinucleata* concerning their morphology, there are differences in their phenology. The most important difference regarding their use as an NTFP is that *I. gabonensis* produces fruit in the rainy season, while *I. tenuinucleata* fruits in the dry season (Ainge & Brown, 2004). They are often referred to as 'rainy-season bush mangoes' and 'dry-season bush mangoes' respectively. However, Ainge and Brown (2004) note that large deviations from this pattern are possible, with some individuals fruiting twice a year or once every two years.

Data on densities of bush mangoes within their range is scarce. A forest inventory of 466 hectares within a 79.000 hectare forest in the Campo Ma'an region of Cameroon found 599 individuals of *I. gabonensis* and 9 individuals of *I. tenuinucleata*, combining to 608 total individuals. Their diameter class distribution is presented in Figure 9 (data from Form International).

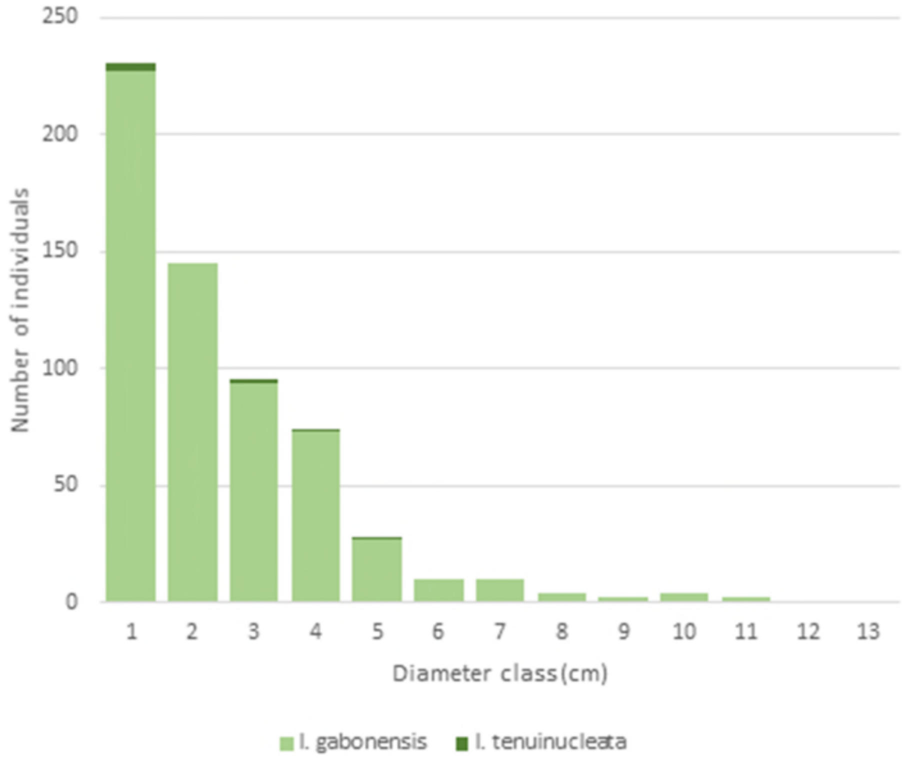


Figure 9: Diameter distribution of I. gabonensis *and* I. tenuinucleata *in Southern Cameroon (data from Form International).*

This data indicates an *Irvingia* density of ~1.3 trees per hectare, the vast majority of which are *I. gabonensis.* Elah et al. (2009) determined a slightly higher density for *I. gabonensis* of 2.1 trees/ha in south Cameroon with a maximum of 3.6 trees/ha. Another study carried out in the Dahomey Gap determined a mean density for *I. gabonensis* of 1.4 trees/ha. The highest densities they found for *I. gabonensis* was 40,8 trees/ha, which was due to a high abundance of *I. gabonensis* trees in home gardens and on farm land. For *I. tenuinucleata*, which is not commonly cultivated, they found an average density of 2.2 trees/ha with a maximum recorded density of 18,5 trees/ha (Vihotegbé et al. 2012). An example of the amount of fruits that bush mango trees can produce per season is presented in Table x:

Table 13: Fruit yield per *I. gabonensis* tree in Nigeria in agroforestry and farm lands (Omokhua et al., 2012).

Farming system	Mean number of fruits per tree	Mean fruit yield per hectare
Traditional agroforestry	620	76,880
Compound farm	850	105,400

This indicates an average seed kernel yield of 18.24 kg for the agroforestry systems and 25 kg for farm lands (Omokhua et al. 2012).

Vihotogbé et al. (2012) identified several possible threats to the conservation of bush mango trees. Apart from overharvesting, they note that flowers and young fruits can get damaged during the harvest through the shaking of branches and the use of sticks and machetes. Moreover, bush mango trees can be severely debarked due to collection for medicinal purposes, and can lose productivity from twig collection for traditional fishing systems. Vihotogbé et al. (2012) also mention that population decline can occur due to sapling and seedling clearing for the establishment of fields or during the collection of other NTFPs. The degree to which these practices actually damage trees differ geographically and are dependent upon the local use of the tree, with the highest percentage of impacted trees occurring in home gardens and close to fishing villages. Trees in natural forest systems were impacted to a lesser degree (Vihotegbé et al. 2012).

Respondents from Cameroon in Ofundem et al. (2017) expressed that the effects of anthropogenic threats on *Irvingia* spp. did not influence resource availability. This may be due to conservation of bush mango trees during land conversion and due to cultivation and conservation of trees on farm lands (Ofundem et al. 2017). The IUCN Red List is of no further in understanding the conservation status of bush mango trees: *I. gabonensis* is mentioned as Near Threatened on the IUCN Red List but that classification stems from 1998 and is flagged as 'in need of revision'. *I. tenuinucleata* is not mentioned in the Red List at all.
What is clear, however, is that bush mangoes are an important foodstuff for many rainforest animals including red river hogs, rat moles, porcupines, red deer, blue duikers, squirrels, forest elephants, birds, monkeys and apes (Beaune et al. 2012; Nfornkah et al. 2018).

Many of these animals are also important seed dispersers for *Irvingia* spp., thus indicating mutualistic relationships. Most notably the forest elephant, which consumes the *Irvingia* fruits whole and is able to defecate complete and viable seeds that can thereafter germinate (Nfornkah et al. 2018). The effects of bush mango harvest on these animals as well as the effect of animal populations upon bush mango dispersal should be taken into consideration during organisation of large-scale *Irvingia* spp. harvest. This is especially the case when bush mango collectors are known to hunt for bush meat during bush mango collection expeditions, as was documented for the Korup National Park in Cameroon (Forje et al. 2019).

This has the potential to negatively impact *Irvingia* spp. through both a loss of seeds by fruit collection and a loss of dispersal through loss of frugivores.

6.4.3. Characteristics of harvest and value chain

During an inventory of the uses of NTFPs in the TPF in Cameroon, it was found that *Irvingia* was the second most important genus used by local communities after *Piper*. Moreover, 59% of the generated income in 31 villages in the TPF was derived from the collection of bush mangoes (Zapfack et al. 2001).

Bush mango harvest signifies a large percentage of household income in Cameroon for collectors (30-50%) and traders (50-70%) (Ofundem et al. 2017). Ingram (2009) estimated the share of household income generated by bush mangoes by collectors to be 25%. Moreover, she notes that 30% of the harvest is auto-consumed.

Bush mangoes are collected both from farm land and home gardens as well as from primary and secondary forests. Ladipo (2003) determined that in Nigeria, approximately 40% of the harvest stems from planted trees from farms and farm gardens, with 60% being collected from wild individuals. *Irvingia* spp. fruit harvesting is a job primarily carried out by women, children and young adults, although men help when climbing is involved (Ndoye 1997; Ndoye 1998). Women are also most involved in the processing of the seeds and kernels in both Cameroon and Nigeria (Lapido 1998). The drying of *Irvingia* kernels takes approximately 2-3 sunny days. Thereafter, they can be stored for months (Forje et al. 2019).

In Cameroon, there are villages that have developed local governance around the collection of bush mangoes. This is the case for various villages around the Takamanda Production Forest (TPF). The rules include a registration fee for collectors from outside of the village, as well as a buyer's contribution. Moreover, the rules require collectors to stay within the village boundaries and put an upper limit on consecutive days spend collecting, as well as stating that collection from farms or already collected fruits it prohibited (Nfornkah et al., 2018).

In Nigeria, where the bush mango trade is more developed, all wholesale traders are required to register with the bush mango association before they are allowed to sell their produce. In 2013, the registration fee was 30.000 CFA (and 36 bottles of beer) to 60.000 CFA for a lifetime membership depending on the market (Ofundem et al., 2017). Ofundem et al. (2017) also identified a processing and packaging enterprise in Mutengene that used mechanical techniques to produce cubes of fried kernel paste. A carton of cubes (1200 cubes) was sold locally for 10.000 CFA in 2013, with the weekly average production for this specific plant increasing from 38-104 cartons to 84-250 cartons in 2013 (Ofundem et al., 2017).

Additional or alternative *Irvingia* seed processing is variable. An example from a technical dossier on *Irvingia* by Cambridge Commodities Ltd. mentions that they buy ready-made seed kernel extract in powder form which they then test for food safety regulations, concentrate, sieve, mix, pack and thereafter store (https://www.cambridgecommodities.com/ugc-1/pdfs/spec-09046.pdf).

6.4.4. Estimate of potential and actual market size and key actors

African market

An inventory in South-west Cameroon found no existing market for the trade in fresh fruits, even though collectors were known to eat them (Ofundem et al., 2017). Seed kernels, however, were found to be sold by collectors to local merchants, intermediaries and wholesalers. This last group includes trans-border traders who are known to employ agents that act as intermediaries to purchase kernels from collectors (Ofundem et al., 2017). Moreover, retailer/wholesalers exist in Cameroon who are also known as Buy'am/Sell'ams. This group include small-scale operators who go door-to-door as well as large-scale operators who conduct transactions in large quantities (Ndoye et al., 1998). This network of actors in the bush mango market chain is visualized in Figure 10 (Elah, 2010).

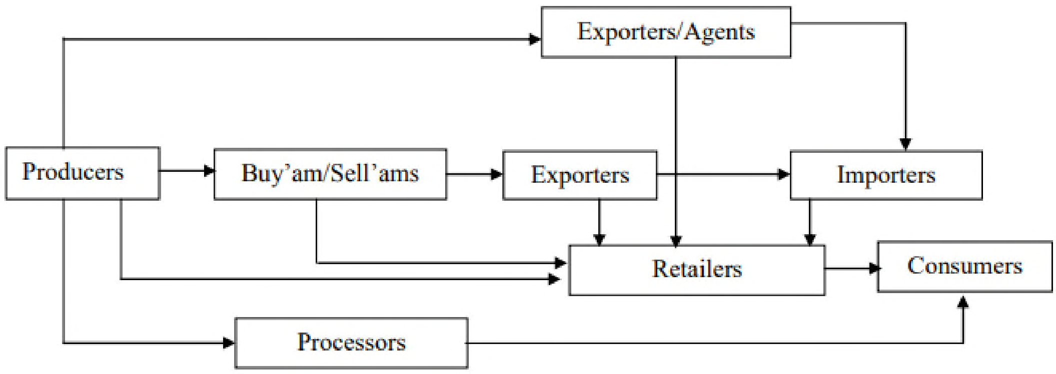


Figure 10: Bush mango market chain in Cameroon. From Elah 2010.

The demand for bush mangoes overshadows the supply, with 99% of producer respondents in Nigeria stating that they have easy market access (Chah et al. 2014). Overall, Ingram (2009) reported that 533 tonnes of *Irvingia* spp. products were produced in Cameroon in 2007, valued at $338,905. However, a contemporary source estimates the bush mango production as being much larger, stating that the export of *I. gabonensis* to Nigeria from Cameroon alone was close to 2.5 million kg (Awono et al. 2009). An older source compiled information of production estimates for *I. gabonensis* per producer in the lowlands of Cameroon, which are summarizes in Table x (Ayuk et al. 1999).

Bush mango kernels are usually transported from the production site back to the village on foot, although transport by motor and truck does occur, especially when larger quantities are concerned. Transport by canoe also occurs in riverine areas, although this drives up transportation costs considerable (Elah 2010). As mentioned before, kernels are then bought by traders and can be exported. Bush mango export from Cameroon mostly ends up in Nigeria, with the three main export markets being Watt market, Ikom market and Eke-Aba market (Elah 2010).

Table 14: Mean annual production estimates for *I. gabonensis* in lowland Cameroon in kg per producer as well as values in CFA/kg (from Ayuk et al. 1999)

Mean annual production	**Department**					
	Lekié		Haut Nyong		Mvila	
	Fruits	Seeds	Fruits	Seeds	Fruits	Seeds
Total	112	32	835	27	165	110
Sales	23	15	328	12	90	56
Consumption	54	17	456	15	73	9
Other (e.g. gifts	35	0	51	0	2	5
Value						
Start-of-season price	130	705	25	230	135	695
Mid-season price	40	300	15	135	45	355
End-of - season price	80	585	10	230	70	325

Non-African market

As mentioned before, the existing international market for *Irvingia* spp. is focussed on dietary supplements that market the positive effect that *Irvingia* seed kernel extract have been shown to have on body weight and metabolic parameters (Ngondi et al. 2005; Ngondi et al. 2009; Azantsa et al. 2015; Méndez-Del Villar et al. 2018). These supplements are based on *Irvingia* kernel extracts, often only from *I. gabonensis*, and can be purchased in Europe through various (alternative) health-centred web shops including lifeextensioneurope.com, superfoodies.nl and luckyvitamin.com.

Seeds can be imported through exporters and wholesalers that predominantly reside in Cameroon, Nigeria and India. The current price per kg of seed kernels that can be purchased via internet varies widely from less than USD 1.17 per kg to more than USD 1,050 per kg. Exports of *Irvingia* spp. products from Central and Western Africa to France, the United Kingdom and Belgium were estimated at US$2 million in 1999 (Awono and Ngono, 2002), a number which has undoubtedly increase over the 20 years since.

There is much opportunity to widen the market for *Irvingia* outside of Africa. The kernels have a pleasant flavour slightly akin to cashew nuts with a lingering bitterness. Their pleasant taste and hypothesized health benefits, as well as their appearance which fits into the stereotypical appearance associated with nuts in general could mean that whole dika nuts could be successfully marketed in Europe and beyond. Moreover, their many potential health benefits could be capitalized upon by the pharmaceutical industry after the production of convincing scientific evidence.

6.4.5. Identification of (potential) off takers

The international *Irvingia* market is still small. As such, there are no obvious major off-takers. Multiple suppliers of raw nutritional materials are known to import *Irvingia* spp. This includes Fifth Nutrisupply and Cambridge Commodities. Upon substantiation of the health claims attributed to *Irvingia* seed kernels, it could become an ingredient in relevant medication and therefore be imported by Active Pharmaceutical Ingredients suppliers (e.g. Pfizer, Novartis, Sanofi). As of now, these health claims have already led to the use of *Irvingia* seed extracts in weight loss supplements. Several of the largest supplement companies in the world, among them the Blackmores group, already produce products containing *Irvingia* seed extracts.

6.4.6. Available information on prices/qualities

Bush mango prices are dependent upon the quality of the seed kernels. There are four general quality gradings for bush mango seed kernels which attract different market prices. The most attractive and valuable kernels, grade one, are obtained by gathering freshly fallen fruits that are opened with a knife immediately after collection. The kernel is then removed and dried in the sun for 2 to 5 days depending on the heat intensity. Grade two kernels are obtained when fruits are gathered and then left to rot for approximately one week. The mesocarp can then be squeezed off the seed and the kernel extracted. Seed kernels that are extracted this way are less clean than grade one kernels. Grade three kernels are obtained by leaving the fruits to rot for three weeks or more, by which time the germination process has commenced and food reserves are starting to be transformed. This lowers the nutritional value of the kernels. Grade four kernels are obtained by drying the seeds directly over a fire. This will result in oil leaking out of the kernels, thereby producing an unattractive product with dark, oily spots. Due to improper storage, loss of quality can occur through which kernels can become lower-grade products. (Nkwatoh et al. 2010)

The average price for *Irvingia* spp. kernels across the grading systems fluctuates throughout the harvest season. In Cameroon in 2010, the cost price for a 15-litre bucket of kernels lay between 10,000 and 18,000 CFA at the start of the season. During the season's peak, prices drop to 5,000-12,000 CFA, to then increase again to 12,000-22,000 CFA at the end of the production season (Nkwatoh et al., 2010).

An alternative grading system based on classification by traders is proposed by Ofundem et al. (2017): grade A kernels are obtained from *I. tenuinucleata* kernels from seeds that are split before drying. Grade B kernels are obtained under similar circumstances, but from *I. gabonensis*. Grade C kernels are those from either species that are derived from rotting fruits from which the seeds are extracted and dried, after which they are cracked. These have a duller appearance than grade A and B kernels. Grade D kernels are also obtained from rotting fruits, but the seeds are not dried and the kernels extracted immediately, often breaking them in the process.

Cost prices differ depending on the kernel grade. In 2013, grade A kernels fetched 2,500 CFA/kg, while grade C was sold for 1,500 CFA/kg during peak season. However, during the off-season grade A and B kernels are not available and the price of grade C kernels rose to 4,000 CFA/kg. Grade D kernels prices were 1,200 CFA/kg. During peak season, a sack (18 kg) of grade A kernels was sold for 25,000 to 45,000 CFA and grade B for 20,000 to 30,000 CFA. Scarcity during the off season could push prices up to 70,000-80,000 CFA per sack (Ofundem et al. 2017). Prices paid for bush mango kernels increased along the market chain, and are recorded for the years 2012 and 2013 in Table 13 (Ofundem et al. 2017).

Table 15: Average price per kg (CFA) for 'sweet bush mango' (I. gabonensis) and 'bitter bush mango' (I. tenuinucleata) in 2012 and 2013 in Cameroon. From Ofundem et al. 2017.

Market type	**Sweet bush mango CFA/kg**		**Bitter bush mango (CAF/kg)**	
	2012	2013	2012	2013
Local	1,610	1,650	2,216	2,400
City	1,940	2,500	2,400	2,700
Trans-border	2,666	3,300	3,300	4,450

Table 16: Potential of Bush Mango collection for concession areas.

Hectares	Seed kernel yield	Market value average (forest site) US$	Market value (international) US$
100	128	90	1,017
1,000	1,280	900	10,170
10,000	1,2800	9,000	101,700

6.4.7. Success factors for SFM operators

As mentioned earlier, *I. gabonensis* fruits in the wet season while *I. tenuinucleata* fruits in the dry season. The wet season is usually the lean season for SFM operators. However, harvesting bush mangoes in the dry season does have the advantage that seed kernels can be dried much easier. During the rainy season, the risk of postharvest losses due to humidity increases (Nfornkah et al. 2018). Moreover, the fruits of *I. tenuinucleata* tend to fetch a higher price when processed properly and (Ofundem et al. 2017) and transport of produce in the rainy season is complicated due to restricted access of roads and rivers (Ingram 2009). On the other hand, holiday season for most forest workers coincides with the lean season, making them unavailable for *Irvingia* collection.

Thus, the collection of *I. gabonensis* could pose an interesting opportunity in the lean season, but the success of such ventures will be highly dependent on the availability of storage space and equipment for seed drying and upon the reliability of the infrastructure around the concession in question. Additionally, it will have to be carried out by an alternative workforce, given that forest workers will generally be unavailable.

SFM operators could maximize their margin on the bush mangoes by saving part of their harvest, mostly the lesser graded *I. gabonensis*, and leaving these fruits rot after which the kernels can be dried. This way, part of the kernels can be sold in the off season and will fetch a higher price while simultaneously spreading the income generated from the bush mango harvest over a larger part of the year. However, this will only be possible if appropriate storage for the kernels is available, given that harvest loss to pests and rodents is a serious concern (Chah et al. 2008).

Hereafter follows a simplified estimate of the costs and revenue that would be involved in *Irvingia* collection in a logging concession given the available data. *Irvingia* densities are estimated at an average of 2 trees/hectare in a natural forest. It is assumed that a quarter of those are too young to bear fruit, leaving 1.5 fruiting individuals/hectare. Seed kernel production in agroforestry and farm lands is ~18 to 25 kg per tree respectively. Given that trees in a concessions will be in a more natural, and thereby more shaded matrix, fruit yield is probably lower. In this context, 15 kg per tree is chosen. The estimated seed kernel production per hectare would then be 22.5 kg (from ~550 kg of fresh fruits). Given a concession of 20,000 hectares of accessible forests, 110,000 tons of fruits and 450 tons of seeds are available. Price data from 2013 suggest a city market price of USD 4.46 (2,500 CFA) per kg for *I. gabonensis*, the more abundant bush mango species (Ofundem et al. 2017). It can be assumed that this has since gone up. As such, USD 5.85 per kilo will be used here. Assuming that 50% of available seeds can be collected (225 tons, from 55,000 tons of fruit) to account for missed opportunities and to avoid sustainability issues, revenue from *Irvingia* sales could be approximately USD 1,316,250 or 718 million CFA (USD 65.81 or 35,900 CFA per hectare) if sold unrefined and without deducing any costs.

There is no data on the amount of *Irvingia* that can be collected and processed in one working day by one person upon full-time harvesting. One kilo of processed seed production per working day is assumed. This would amount to 225,000 working days, or 11,250 months (assuming a five-day workweek). According to globallivingwage.org, the minimal living wage in Cameroon is 105,000 CFA (USD 188.4) per month, and 43,200 Naira (USD 130) in Nigeria. Labour costs would be 1,181 million CFA (~USD 2,106,000) per growing season for Cameroon, and 486 million Naira (~USD 1,170,000) for Nigeria. That does not yet take into account costs for packaging, transport, equipment, etc.

Thus, in this hypothetical scenario which assumes the sale of seeds at city markets and employment of personnel that is paid a living wage, *Irvingia* harvest is not a profitable venture. However, it must be noted that this scenario is based on assumption and includes data that is not up to date. If the price of *Irvingia* seeds is currently higher than assumed here, for example USD 8.2 (~4,500 CAF) per kg, the total possible revenue would be USD

1,842,750 or ~1 billion CFA. That would open up possibilities for Nigeria and other countries with similar living wages.

Moreover, *Irvingia tenuinucleata* is cultivated in some areas of Cameroon, mostly on cocoa and coffee farms, where it is planted at densities of some 100 trees/ha. Within such a system, the profitability of bush mango production is greatly improved (UEBT, pers. comm.).

6.4.8. Legal aspects

Africa

Legislation regarding the collection, trade and export of *Irvingia* spp. differ per country, and relevant information is not always available, as is the case for Nigeria.

In Cameroon, a tax of US$0.018 per kg is imposed on all NTFPs as well as a 5% fee on all exported NTFPs, as stated in Article 11 of the 1999 Finance Law (Chupezi & Ndoye 2006). Moreover, an exploitation permit is compulsory for large-scale exportation of NTFPs, which specifies the quantity that can be exploited or collected in a certain geographic area. The allowed amount is determined by the Department of Forestry and authorized by the Minister of Forestry and Wildlife. Permits are usually given out for the period of one year (Sunderland 2001). The maximum quota for bush mango collection under 1 permit was set at 100 tons in 2009 (Elah 2010). Traders and exporters in bush mangoes without a permit often fall prey to serious corruption by police officers, forestry officials, customs, council, commerce and quarantine officials. Even with permits, respondents in Elah (2010) mention widespread corruption along the harvest and market chain.

In Gabon, collection and use of NTFPs is regulated through the Forestry Code No 16/01, which was supplemented by various subsequent decrees (000692/PR/MEFEPEPN, 001029/PR/MEFEPEPN, 137/PR/MEFP). These decrees state that *I. gabonensis* trees may not be logged for a period of 25 years, ending in 2034. Moreover, they establish that NTFPs can be freely collected by local people. Commercial collection, on the other hand, requires a permit issued by the director general of the forestry department. The permit applications must be accompanied by information on collection methods and area, as well as on points of sale. (Iponga et al. 2018)

EU

The access of *Irvingia gabonensis* seeds to the EU food market is not subject to the EU Novel Food Regulation, since it was already consumed on large scale before 1997. Still, member states have the opportunity to restrict the market access through additional legislation and it can thus differ between countries. Moreover, in the Negative List for Novel Foods and Ingredients as published in 2014, it was mentioned that *Irvingia* fruits (including extracts) and non-aqueous seed extracts are not yet authorized as food (ingredients). *I. tenuinucleata* is subject to the EU Novel Food Regulation and has so far not been approved.

Additionally, food ingredient in the EU must meet various requirements regarding food safety, including process hygiene criteria and microbiological criteria (https://ec.europa.eu/food/safety/biological-safety/food-hygiene/microbiological-criteria_en).

6.4.9. Sustainability, Certification and Ethics

A study by Toda and Yasuoka (2020) drew attention to the fact that bush mangoes in southeast Cameroon are often harvested by Baka hunter-gatherers who sell or trade them to Bantu famers whereby the latter obtain seven times the net profit compared to the former, creating significant wealth disparity between the peoples. It is therefore of the utmost importance that the relationships between the peoples in the harvest process is monitored when bush mangoes are harvested on a large scale.

More generally, bush mango producers in Cameroon reap a very low margin on their produce (although even within Cameroon, this varies greatly) due to several factors. Most importantly, there is a lack of knowledge regarding optimal processing methods. Additionally, harvesters often lack market information and facilities to store seeds or kernels at the village level, which leads to quality degradation. (Nkwatoh et al. 2010) Supplementing harvesters with this knowledge and the necessary facilities can increase the kernel grade they produce and can therefore aid them in acquiring a sustainable livelihood from bush mango kernels.

6.4.10.SWOT

Strengths	Weaknesses
• Multi-purpose fruit • Widespread throughout tropical Africa • Not a great species for timber, so no conflicts with timber production • Limited sustainability concerns • *I. gabonensis* is not subject to the EU Novel Food Regulation	• Abundance in natural forests not very high • Many fruits must be harvested for a kilogram of seeds • Current international market is very small • Inequality and ethics-problems associated with production in rural areas
Opportunities	**Threats**
• Market opportunities in Europe/the global North as a novelty nut and in pharmaceuticals (dependent upon sufficient scientific evidence) • Lean season activity in concessions • Could be more profitable in an agroforestry system, and interesting for forest owners with relevant assets	• Seed quality can degrade if drying and storage facilities are sub-par • Employing harvesters at a living wage may not be profitable

7. Commercialisation models for NTFP production in SFM

7.1. Different models for NTFP production

Depending on the volume of the product available and the interest of the forest management company and the level of involvement it would prefer, various models for bringing the product to the market can be proposed and will be shortly discussed here.

Model 1: SFM operator manages the value chain

In the first model, the forest manager will manage the value chain themselves, including a part of the processing with for example a small processing facility. This way there is total control. The value adding will be done by the SFM operator and this may also increase the benefits. In this model there is the need to pre-invest and do marketing research. Moreover, products may have to be stored for a period of time, which includes risks.

Model 2: hiring staff and selling the harvest

Another option is that the SFM operator will not manage the entire value chain, but will instead harvest the product with its own personnel and subsequently sell the harvest to a processing facility. The risks of this model are smaller than when the entire value chain is controlled, but there is still a need to pre-invest and possibly also store, and profit margins are likely (much) lower.

Model 3: strategic alliance with an off-taker

The third model concerns a strategic alliance with an off-taker, which may be an external company or a community organisation. The external organisation will harvest the product on the concession area and the SFM operator will receive a revenue share on the harvested product. This is the lowest risk option.

Certification of the product

An additional activity a forest manager can engage in is certification of the NTFP, independent who is harvesting the product. By guaranteeing to meet the requirements for certification the SFM operator can get a higher price for the product. This is not a separate model, but an additional management step.

There is a big difference in cost and risk depending on the model chosen. Possibly this results in differences in profit as well. Making an alliance with an off-taker looks like an easy way to start up. It may however, proof difficult to later take matters in own hand as the off-taker has built the network for marketing and sale. So when joining forces, it may be difficult to change tactics later.

7.2. How can NTFPs be successfully integrated in SFM?

The products we studied in this report lend themselves for all three models, but uncertainty on how the marketing will develop will push most forest managers to do aggregation work after contact with buyers for the material. Examples do exist however of forest managers turning an NTFP into a significant part of their business model. Samartex in Ghana has for instance developed the extraction of sweetener from Thaumatococcus danielli fruit to a high level (see Boadi et al. 2014) and integrated it in their tree planting program.

From the study it has become clear that the international market is not aware of many of the potentially valuable products that exist in tropical forests. Some products have a well-established market at a national level but are only starting to be explored in a more international setting or are still completely undeveloped. In places where a national market is available a logical step would be to develop a product for that market first and then see if it is interesting to also develop exports.

It seems that forest managers need to be made actively aware of the potential there is in the forest and of course also of what it would take to assume a role in trading NTFPs. Many forest managers will consider products such as Coula edulis as suitable for the local people, without realising there may be opportunities for both the population and the company.

We think it would be very good to develop the concept of NTFP trade for pilot companies in all three areas and for all products. During such a pilot more practical information can be generated on opportunities, conditions and risks. The pilot would consist of:

- Establishing availability of various NTFP inside the FMU
- Picking the most likely candidate
- Present plans to government officials and obtain permits (if needed)
- Establishing contact with potential traders
- Agree with traders in which form the product will be supplied
- Agree on pilot pricing with leaving room to later negotiate a fair price
- Developing the collection / harvesting methods
- Developing the conditioning methods
- Actual shipping and market testing
- Evaluation of process and decision on opportunities

For the products studied in this report, a link has to be established between a forest manager and a trader in the product. For Aguaje, which already has a market, organisations that we have been in contact with could be introduced to parties managing forest containing interesting areas of Aguaje. Although the market for aguaje products also needs to be expanded in order to absorb increased production. For Coula edulis, which does not have a current international market, interest exists and the process can be set in motion with the delivery of a first modest quantity of 100 kg of nuts so that this can be trailed for taste, market potential etc. Damar seems to already find its way to the market and is available in web shops easily. In a pilot it can be determined to what extent it is possible to integrate new suppliers into the supply chain.

8. Discussion of results

The findings from our study demonstrate that several of the NTFPs have potential in the market or are already being marketed to some extent.

When looking at Aguaje we see there is an existing market and that the product is attracting attention from various sectors. Export statistics from Peru show it is a market that generates some US$15 million annually. Aguaje is found in high densities in certain areas and especially in such areas it can be an interesting crop.

Coula edulis is virtually unknown in the international market. It has a good availability in the forest and the potential for its production is high. As a result of discussion held for this study interest has been spiked with a nut trader, who is willing to study the product in more detail. The comparison with a Cashew business case shows that the product has good potential at village level and SFM companies could choose to do harvesting, conditioning and sales or aggregate and sell the produce from villages. The actual price obtained and the actual available volumes will to a large extent determine how interesting this product is for an SFM manager.

Damar has the potential to generate considerable revenue from forests in which it is available. Moreover, it has a large story-telling potential since its production can aid in the conservation of threatened Dipterocarp forests while at the same time supporting local communities.

Irvingia shows a modest chance of being developed further due to the high wage costs associated with collection from natural forests. The planting of *Irvingia* in agroforests, on the other hand, may be profitable, although this will not be relevant for most sustainable forest managers.

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Annex 1: Matrix analysing the various NTFPs

This matrix shows all considered NTFPs during this study, including the most interesting success factors per product. NTFPs that we feel have high potential in the international market are coloured light green. NTFPs with low potential or high risk for the species or environment have been coloured light orange. NTFPs that are already widely established are coloured blue. All others remain white.
The novel food status is as follows: <1997 (green) means the product was know and needs no novel food registry, N (orange) means it is not yet registered and still needs registration for use as a food, a year (like 2019) in green means the year it was registered, and a mention of “FS” in blue means it was known as a food supplement. This all applies for products brought onto the market as food.

Species	scientific name	in logging concessions	harvest system	risks associated with collection	EU Novel Food registered	no cultivation (ex. agroforestry)	large scale possible, without influencing	favourable	no competition from cheap	story potential	Unique properties	No toxic relative	Shelf life	Market access legislation	Farmaceutical	No IP rights	opinion UEBT
Acai	Euterpe oleraceae	yes	in the forest picked by climbing the tree.	occupation hazards (high climb), impact on forest composition through selective thinning in favour of Acai.	N	-	+	+	+	+	+	+	-	+	+	+	Already well-established product with growing market interest. Significant scope for expansion.
Achiote, Urucum	Bixa orellana	no	collecting pods in plantations	not clear	<1997	-	+	+	?	+	-	+	+	+	?	+	Natural red colours are in high demand in the market at the moment, but production from cultivation is already established at a large scale.
Aframomum	Aframomum angustifolium (Aframomum melegueta is known < 1997	yes	either in private plantations or in the wild	not clear	N	-	+	+	+	+	-	+	+	+	+	+	Flavour interesting to make it as a new spice, large local market.
African cherry	Prunus africana	yes	much is still harvested from the wild, though trees are also planted in coffee agroforestry systems	wild collection often kills trees due to unsustainable practises	Non Food	-	-	+	+	+	+	+	+	-	-	+	Threat to harvesting makes this a high risk species from sustainability perspective. Used as a herbal medicine, with long lead times to commercial development.
African plum	Dacryodes edulis	yes	planted in cocoa agroforestry systems. Fruits are picked.	no specific risk	<1997	-	+	?	+	+	+	+	-	+	+	+	Highly perishable fruit make this very difficult to handle.
African walnut	Coula edulis	yes	nuts are collected	fruit collection may impact regeneration	N	-	-	+	+	+	-	+	+	+	+	+	Strong global demand for nuts as a source of plant protein.
Agarwood	Aquilaria spp. / Gyrinops spp.	yes	wild collection	harvest requires cutting of trees and has influence on population.	Non Food	+	-	?	+	+	+	-	+	-	+	+	Negative perceptions around sustainability; can be overcome if sustainable forest management can be guaranteed.
Aguaje, buriti, moriche	Mauritia flexuosa	yes	wild collection	fruit collection puts pressure on natural population (reduction of seed availability) starch required cutting of palm.	N	-	+	+	-	?	-	+	- / +	+	+	+	High demand for this product, which is abundant and can be produced sustainably.
Allanblackia	Allanblackia spp.	yes	Wild collection	seed collection reduces availability of seed in the wild. May ultimately have an influence on population structure locally.	2019	-	+	+	-	+	-	+	+	+	+	+	Relatively low value of Allanblackia products mean it is hard to compete with other large-scale cultivated ingredients.
Andiroba	Carapa guianensis	yes	wild collection	seed collection reduces availability of seed in the wild. May ultimately have an influence on population structure locally.	N	-	+	+	-	+	+	-	+	+	?	+	Potential toxicological issues associated with the traditional use as an insect-repellent. Related to neem, which has similar issues.

Aralu bulu	Terminalia chebula, T. bellirica	yes	wild collection / some cultivation reported	seed collection reduces availability of seed in the wild. May ultimately have an influence on population structure locally.	FS	-	+	+	+	?	+	+	-	?	?	+	High levels of pharmaceutical activity make this a high risk ingredient
Babassu	Attalea speciosa	yes, though mostly available in Cerrado vegetation and cattle pastures (as a weed)	wild collection / some cultivation reported	The species seems to stand intensive harvesting well	N	-	+	+	?	-	-	+	- / +	+	+	+	Negative interactions with thyroid/endocrine system make it unlikely this will be adopted at large scale
Brazil nut	Bertholletia excelsa	yes	wild collection	seed collection reduces availability of seed in the wild. May ultimately have an influence on population structure locally.	<1997	+	+	+	+	+	+	+	+	+	+	+	Already well-established product with growing market interest. Significant scope for expansion
Cajuput oil, gelam	Melaleuca cajuputi	yes	leaves are collected from stands in the wild or from planted stands	not clear	Non Food	-	+	+	?	?	+	+	+	+	?	+	Too similar to both tea tree oil and eucalyptus oil, which are much better-researched and known
Chicle	Manilkara zapota	yes	collection from the wild	not clear	<1997	-	+	+	-	+	-	-	+	+	+	+	South American producers unlikely to compete with commercial Indian production.
Cocoa	Theobroma cacao	yes	collection from the wild	not clear	2020	+	+	+	-	+	-	+	+	+	+	+	Growing market interest in "sustainable" cocoa make this an atttractive opportunity
Cinchona	Cinchona spp.	yes	trees are cut and the bark removed. Tree coppices so can yield several times.	overharvesting do to the need to cut the tree.	Non Food	+	+	+	-	+	-	-	+	?	?	+	High levels of pharmaceutical activity and known toxicological activity make this a high risk ingredient
inoi nut	Poga oleosa	yes	gathering of fruits and extracting the nuts	seed collection reduces availability of seed in the wild. May ultimately have an influence on population structure locally.	N												Strong global demand for nuts as a source of plant protein
Damar	Hopea spp., Shorea spp.	yes	is tapped from the bark.	not clear	N	+	+	+	+	+	+	+	+	?	?	+	Aromatic gums are a small but growing market opportunity worthy of investment
Essouk	Garcinia lucida	yes	bark removal	damage to trees leading to tree death	N	+	_	+	+	+	+	-	+	?	-	+	Threat to harvesting makes this a high risk species from sustainability perspective. Used as a herbal medicine, with long lead times to commercial development
Gutta percha	Palaquium spp.	yes	is tapped like rubber	not clear	N	+	+	+	+	+	+	+	+	+	+	+	Negative perceptions about sustainability and ready availability of alternatives make this an unlikley candidate for success.
Kitul palm, toddy	Caryota urens	yes	is tapped from the palm	high climb.	N	-	+	+	-	+	-	+	+	+	+	+	Rising interest in natural sweeteners and a strong back story
Kola nuts	Cola spp., nitida	yes	seeds are collected	comes from agroforestry systems	<1997	-	+	-	+	+	+	+	+	- / ?	+	+	High potential for use in the beverage industry, building on the kola heritage. Natural stimulants are also in demand.

Manketti, essessang, okhuen	Ricinodendron heudelotii	yes	seed collection	overharvesting may affect recruitment of young individuals in the forest	N	-	+	?	+	+	-	-	+	+	+	+	Primarily used as a low value cooking oil, but hard to complete with cultivated cooking oils
Peru balsam	Myroxylon balsamum var. Pereirae	yes	tapping of gum from the bark of the tree	not clear	N	-	+	?	+	+	+	+	+	- / ?	?	+	Negative European Medicines Agency report makes this a very hard sell
Rattan	Calamus spp., Daemorops spp.	yes	cutting of canes from a clump and stripping of spiny bark.	overharvesting is a great risk in all areas where rattan is found.	N	-	_ /+	=	+	+	-	+	+	+	+	+	Already well-established product with growing market interest. Significant scope for expansion
Rubber	Hevea spp.	yes	tapping of latex from the bark	not clear	N	+	+	+	-	+	-	-	+	+	+	+	More information needed on this very complex and long-established market
Sago	Metroxylon sagu	yes (swamp forest)	cutting stems and scraping our core. Washing the starch out of this.	overharvesting, swamps are vulnerable environments	N	-	_	+	-	+	-	+	+	+	+	+	Excellent market prospects from interesting alternative sources of starch
Sandalwood	Santalum spp.	not clear	selective felling	overharvesting	N	-	+	=	+	+	+	+	+	- / ?	+	+	Negative perceptions around sustainability; can be overcome if sustainable forest management can be guaranteed
Wild Mango	Irvingia gabonensis / wombolu	yes	fruit collection and seed extraction	overharvesting may affect recruitment of young individuals in the forest	<1997	-	+	+	+	+	+	+	+	+	+	+	A promising species for its multiple products with no negative drawbacks, but may not be profitable to collect.
Wild spinach	Gnetum africanum	yes	collected from the wild.	overharvesting	N	-	_	=	+	+	-	+	-	+	+	+	Significant market potential as a novel superfood
Xaté	Chamaedorea spp.	yes	collected from the wild.	overharvesting	N	+	+	=	-	-	-	+	-	+	+	+	Not easily substituted, although the demand is heavily dependent on a single religious festival

Annex 2: Potential off takers of Aguaje in Peru and Brazil

Peru

In Peru we identified some of the main companies that market (organic) Aguaje cosmetics and food products domestically and internationally as can be seen in the table below.

Company information	Description of main use(s) of Aguaje.	Company size & location
Frutama S.A.C. produces organic fruit pulps from the Amazon and links Amazonian producers to the international market. Frutama has created a value chain for Aguaje and other Amazonian fruits and generates economic incentives for indigenous producers in the region to maintain their forest areas.[7]	Organic certified Aguaje pulp. Frutama is a primary processor of Aguaje into pulp in Loreto where it subsequently frozen and sent to Lima.	Size: unknown Location: Maynas, Loreto Annual revenue: of US$ 1.1 million
Candela Perú[8] is an alternative trade organization, founded in 1989, dedicated to the transformation and commercialisation of organic products, contributing to the development and strengthening of value chains based on Peruvian biodiversity.	Organic Aguaje oil (domestic market)	Size: 19 employees Location: Villa el Salvador, Peru
AJE Group[9] is a multinational beverage company that owns several different brands, including the Bio Amayu brand, that makes use of Aguaje.[10] The company has a focus on sustainability of its products.	A "superfruit" juice that includes Aguaje.	Size: 13,000 direct and indirect employees. 4th largest non-beverage company in sales volume in the countries in which they operate. Location: in Peru in Lima. Sells products in 23 countries

[7] See: http://canopybridge.com/members/frutamas-a-c/profile/
[8] See: https://www.candelaperu.net/
[9] See: https://www.ajegroup.com/
[10] See: https://www.bioamayu.com/

Amarumayu a Superfruit Juice Company active in the Peruvian Amazone. The company works with local communities in collaboration with the Peruvian service for national protected areas (SERNANP) in the Pacaya Samiria National reserves to produce superfruit juice drinks for the global market. [11]	A "superfruit" juice that includes Aguaje.	Size: unknown Location: Peru
Agroindustrial Floris SAC, commercially known as Santa Natura[12] is a Peruvian company that sells natural food supplements on the domestic and international market.	Supplement that includes Aguaje.	Size: 110 employees Location: Lima, Peru

Brazil

In Brazil the main offtakers for the national and international market of Aguaje, or Buriti, are cosmetic companies that either sell buriti oil directly, or make use of the oil in their cosmetic products. Some of the main companies in Brazil are Citróleo Group, Amazon Oil, Destilaria Bauru, Beraca, Bergamia.

Company information	Description of main use(s) of Aguaje	Company size & Location
Citróleo Group is a large Brazilian company that offers natural and sustainable products to a wide range of personal care, cosmetics, pharmaceutical, home care and fragrance products and are distributed to all regions of the world.	Aguaje oil. The company website notes that an estimated 500 people are directly and indirectly involved in the production of the oil from treatment in the field of the fruit up to the final extraction of the oil. The company also mentions to support the oil producing communities in several ways[13]	Size : Unkown Location: Torrinha, SP, Brazil
Amazon Oil process oils and butters from the Amazonian	Virgin buriti/aguaje oil. The oils produced from Amazonian	Size: 11-50 employees

[11] See: https://amarumayu.com/

[12] See: https://santanatura.com.pe

[13] See: http://citroleogroup.com/site2017/os-encantos-da-amazonia-diretamente-da-arvore-da-vida-oleo-de-buriti/

rainforest. They guarantee 100% pure and natural, cold-press extraction from wild harvested products.[14]	oilseeds are used by the cosmetic, pharmaceutical, food, and textile industries in perfumes, toiletries, beauty products, as dyeing and emollient additives in textiles, as well as ingredients in foods.	Location: Belém, North Brazil
Destilaria Bauru is a producer, importer and exporter of various essential and vegetable oils, mainly for the cosmetics industry in Europe, the US, China, and other countries.[15]	Extra virgin, cold pressed Aguaje/buriti oil	Size: unkown Location: Cantunduva, San Paulo
Beraca natural ingredients is a wholesaler that produces sustainable products and services for the cosmetics, pharmaceutical and personal care industry worldwide.[16]	Sustainably sourced, organic Aguaje oil.	Size: 90 employees, sales of US$ 15 million in 2020. Location: San Paulo Brazil. International offices in France and US.
Bergamia a certified B-Corp cosmetics company with natural, organic and vegan skincare.[17]	Creams and balms with Aguaje oil and other products.	Size: unkown Location:

[14] See: http://www.amazonoil.com.br/pt/buriti/
[15] See: https://www.destilariabauru.com.br/
[16] See: https://www.beraca.com/
[17] See: https://bcorporation.net/directory/bergamia; https://www.bergamia.com.br.

Annex 3: Other species to complement the Aguaje business case

Patawa (*Oenocarpus batau*)

The *Oenocarpus bataua*, commonly known as Patawa, Patauá or Bataua, has many similarities to the *Mauritia*. The Patawa is a palm tree which grows on dry land and in humid forests and which occurs in the wet areas of the Amazon of Peru, Brazil, Bolivia, Colombia, Ecuador, Venezuela, as well as Trinidad and Panama (Montúfar et al., 2010). The palm is 25 meters high and like the *Mauritia*, grows large bunches of fruits on flower stalks. Patawa fruits are used for a variety of food products and are used to make oil that can be used for cooking as well as for cosmetics. The oil is comparable with olive oil. The main harvesting season in Brazil is estimated between January-July, which coincides with the harvesting season of Aguaje in Brazil (SEMA 2019; Amazon Oil, 2021b).

Murumuru (*Astrocaryum murumuru*)

Murumuru is another dominant palm species that grows throughout the Amazon, and which is very common in Brazil, especially on riverbanks. It is a small palm tree which grows small edible fruits. The fruit is a local food source, but it is commonly processed into murumuru butter of murumuru oil, which is used from cosmetics like soaps, creams and shampoos (Galdino 2007). Murumuru is also used by various identified off-takers of Aguaje such as Amazon Oil, Bergamia, Amaramayu. According to AmazonOil the market of the product is increasing.

Babassu (*Attalea speciosa*)

The Babassu is another palm species that grows in the Amazon, and which is very common in the Maranhão and Piauí states of Brazil. It is an evergreen palm between 15-30 meters high that grows large bunches of fruits that resemble small coconuts. Mature fruits start to fall between August and November until the rainy season in January and February. Like the *Mauritia*, the babassu is used for all sorts of purposes. Its seeds are used to produce babassu oil, used for cooking, detergents, lamp oil, and in cosmetics. The babassu fruits are also used to produce traditional medicine, drinks, and flour, and its leaves and stalk are used for building materials and to make handicrafts (Heuzé et al. 2016). Babassu products are marketed internationally, mainly within cosmetics.

Andiroba (*Carapa guianensis*)

Another species of interest could be the Andiroba, a canopy tree that grows in the moist forests of the Amazon as well as in Central America and Africa. Andiroba timber is an appreciated timber species often part of species harvested by SFM companies. The oil extracted from the kernel is used as a powerful insect repellent and for traditional medicine (Plowden 2004). It is considered one of the most popular oils produced in the Brazilian

Amazon and is also produced by wholesaler AmazonOil. The Brazilian cooperative Coopfrutos that works with Aguaje also processes Andiroba oil on a small scale (SEMA 2019).

Sacha Inchi or Inca nut (*Plukenetia volubilis*)

Part from the above palm oils, Sacha Inchi or Inca nut could be another NTFP that could be part of a baskets of an NTFP harvest and value chain unit. It is a vine native to the tropical rainforest of Peru, Colombia, Venezuela and Brazil (Ferreira Valente et al. 2017). The plant produces large edible seeds and has been used by the indigenous people of Peru for centuries. The nut is a widely commercialised plant species, but also cultivated (which could complicate the economic viability of forest harvests). Its oil, extracted from the seeds is a popular product used for skin and hair care, and Sacha Inchi seeds are also used as a food product and as a dietary product as a result of its high omega 3 and 6 content.[18] Peru is the main producer of Sacha Inchi especially in the regions of San Martin, Ucayali, Loreto and Junín, and the product is also in other regions of Peru and in Colombia.[19] Although the plant occurs in Brazil, there is no well-developed value chain of Sacha Inchi in the country. Sacha Inchi oil and other products are exported worldwide and the demand for the oil is increasing domestically and internationally.[20]

[18] https://sigmaoilseeds.eu/products/sacha-inchi/

[19] https://www.scielo.br/j/pat/a/hqqP8fwK4Bcqqh8GWqpkRJD/?lang=en&format=pdf; https://www.intracen.org/Market-analysis-for-three-Peruvian-natural-ingredients/

[20] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6801255/