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Palm Oil production in Bombali District

Northern part of Sierra Leone

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Introduction

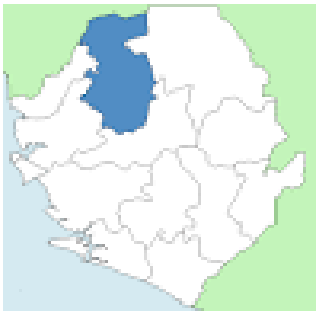
Palm oil (*Elaeis guineensis*) originates from West Africa areas, stretching from, Guinea to Cameroon, including the equatorial regions of Angola and Congo (FAO). In Sierra Leone, palm oil is fully part of the local culture. The tropical climate is favourable to its natural growth and the population exploits palm trees for years. According to Jacquemard (1998), "*By 1936, nearly half of total world exports of palm kernels was provided by Nigeria and nearly one tenth by Sierra Leone*". Even if nowadays South-east Asian countries have largely overpassed the African continent, palm trees plantation remains important for the Sierra-Leonean farmers all over the country; its typical outline is even present next to the lion on the national emblem.

Palm trees produce more oil per hectare than any of the oil crops (Adeniyi & al. , 2014). In Sierra Leone, it is a major staple food and source of lipids for the rural population. Its high contain of carotene gives a characteristic red colour to the local dishes. By-products are also used for different purposes: kernel for palmist oil and soap, leaves and wood for light construction and fencing, sap for palm wine…

For smallholder farmers of Bombali district, located in the north of Sierra Leone, palm oil plays an important role in their farming systems, contributing to ensure their food security and to generate incomes. As compared to south Sierra Leone, the productions are mainly dedicated for the local markets because of the climatic conditions that are less conducive than in the south where an important part of the production is exported.

Findings of several works related to palm oil production in Bombali District and experiences on the promotion of processing techniques using palm oil pits, have been summed-up in a set of 3 complementary documents. This first document focuses on a review of the different evolutions of the cropping of palm trees in the North or Sierra Leone. It also presents the biology of palm oil and its main by-products, the traditional cropping and processing practices as well as an analysis of the local market of the different by-products and their role in the farming families' economy.

a. Historical review



To our knowledge, data on national oil palm production is not available in Sierra Leone. Palm trees are naturally present across the country but large scale industrial plantations are concentrated in the southern districts (Bonthe, Bo, Kenema, Kailahun and Pujehun), which offer optimum weather conditions for oil palm: a minimum rainfall of 1800 mm, well distributed over the year (Jacquemard & al., 2011).

This study focuses on the Bombali district, where rainfall is sufficient (1800 to 2000 mm) but the distribution pattern is too irregular to get optimum yield (6 months long dry season). However, as will be seen in this part of the study, oil palm plays a fundamental role in the families' farming systems, with a production that is primarily dedicated to local markets.

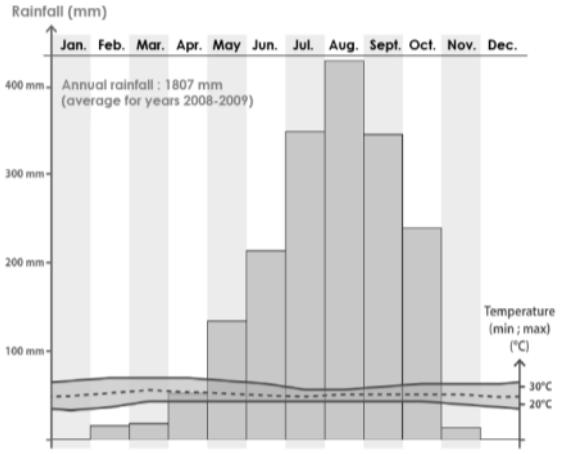


Figure 1 - Ombro thermic graph. Source: adapted from Pallière (2014)

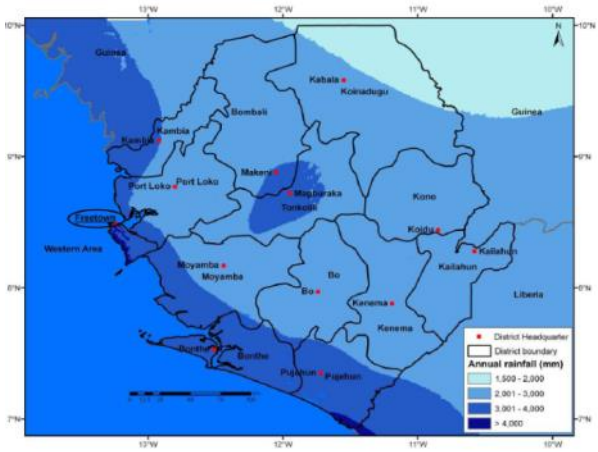


Figure 2 - Annual rainfall distribution in Sierra Leone. Source: Asamoah (2011)

Travelling in the Bombali district rapidly shows the high importance of palm trees as crop in the area. These easily recognizable trees are present everywhere in the scenery: along swamps, scattered in dry lands but also lined up in dense plantations. After an expedition across the Sella Limba chiefdom in 1925, Migeod already mentioned the presence of palm trees (Pallière, 2014). Despite farmers exploiting forests with the slash and burn technique, wild palm trees have been preserved, resulting in the development of a sub-spontaneous palm grove, accessible to everybody and exploited in different ways (leaves, soap, and oil).

From the establishment of the British protectorate in 1896 onwards, the local population had to deliver palm kernels as payment of local taxes (Pallière, 2014). Thus, by 1936, Sierra Leone was a major actor on the international stage regarding palm kernels' export (Jacquemard, 1997). From 1949 to the sixties, the Sierra Leone Producer Marketing Board (SLPMB) had the monopoly on purchasing palm kernels. For farmers in Sella Limba, it was the main source of income until the 1970s. After a fall in prices, the marketing of palm kernels was stopped and the product was reserved for personal consumption (Pallière, 2014).

The SLPMB launched an industrial oil palm plantation in Daru in 1967, which the government took control of in 1973 (Sesay, 2014). The company then started to buy fruit from out-growers, stimulating the dynamic of small-scale plantations in the surrounding communities.

Other companies, looking for suitable environmental conditions, were established in the southern part of the country (Cambia/Matru Oil Palm and Masankay Oil Palm Company based in Tonkolili

district). They generated a ripple effect leading to the development of oil palm plantations, whereas no company settled in the northern part of the country.

In Bombali, palm trees naturally developed in areas which were protected from fire and where water was sufficient, especially along swamps. At that time, the population density was lower than now and it can be assumed that villagers extracted enough oil to cover their basic needs by exploiting wild trees (and preserving new sprouts). Indeed, the palm grove could provide oil for up to 170 inhabitants/km² while in 1980 the population density was about 70 inhabitants/km² in Sella Limba (Pallière, 2014).

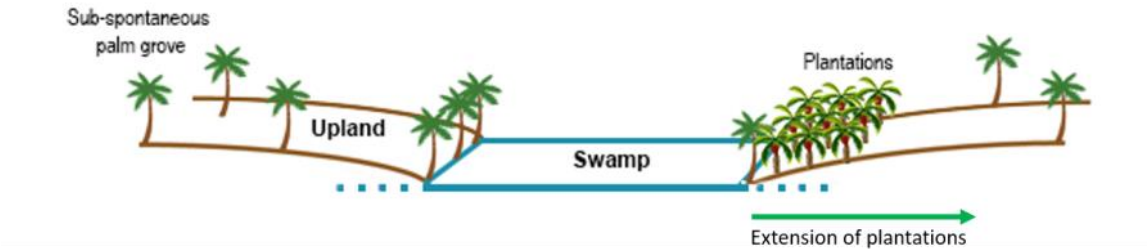
According to Pallière (2014), the plantation process in the Bombali district was initiated by the Rokel Leaf Tobacco Development Company, founded in 1973. That British company convinced numerous farmers to start the production of "dark fire curded" tobacco. One of the conditions to receive seeds and fertilizers on credit from the Rokel was to remove all trees from their cultivation plot. Moreover, after the harvest, tobacco leaves of this variety had to be dried in an oven fed with firewood. These two practices led to deforestation and rural families started to complain and express their concerns. To avoid conflicts, the Rokel decided to provide seedlings of Gmelina spp. (a fast growing tree mainly used for timber) and oil palm trees as compensation (Pallière, 2014). Interested farmers received about twenty palm trees each and then extended their gardens by themselves. The company closed their doors in 1991, when the civil war started.

In the nineties, the NGO Action Aid launched a project on palm oil. Nowadays, lots of farmers who own palm tree gardens in Sella Limba have started to plant with that organisation. Each farmer received an average of 20 - 40 seedlings for 500 Le/seedling. At that time, the Action Aide project field officers advised farmers to plant in line at a density of 30 feet by 30 feet and this practice is still the most common one nowadays. It should be made clear that the seedlings provided by Action Aid were not improved ones, but rather a mix of Dura, Pisifera and Tenera. This is a very relevant fact to understand the current state of affairs in the area, as will be shown later.

In Sanda Loko chiefdom, Mr. Thomas Borbor Turay, currently Honourable Member of Parliament, also played a major role in the development of gardens. He is the founder of a local NGO called PARD which also started to provide seedlings to farmers after he imported seeds from other districts of Sierra Leone and Malaysia. The NGO still carries out this activity under the responsibility of Mr. Borbor Turay's brother. To our knowledge, no programme took place concerning oil palms during the civil war (1991 – 2002). The dynamic of plantation continued, farmers using their own fruit to extend their gardens.

Producers have now extended their gardens and their sons have also started planting. The process is more or less developed depending on chiefdoms because traditional authorities enforce different rules regarding palm oil plantations and the exploitation of sub-spontaneous palm grove. To start a plantation, the farmer has to own the land. Some chiefs therefore do not accept to concede land for this crop because they want to keep control of land resources. This is particularly true in some parts of Sella Limba chiefdom.

Palm oil trees require water, so the first plantations were installed near swamps. Now, this agro-ecological zone is almost saturated, so farmers have started to plant oil palms on uplands, although those lands are poorly suited to oil palm cultivation.



At the same time, the fallow duration has decreased due to the population growth, and fires have damaged the sub-spontaneous palm groves, with numbers of trees dwindling. However, farmers have continued to plant palm trees. This may be linked to a better access to markets. On the one hand, the growing proportion of non-farming families within the total population has led to a new demand for agricultural products (vegetables, rice, palm oil). On the other hand, the improvement of the road between Makeni and Kamakwie has created new opportunities and outside traders have started to come to buy oil and sell it to Makeni. Wild trees are still present in the landscape but their role in oil production is decreasing. Nevertheless, the population highly appreciates the oil produced from those trees and tries to preserve them as much as possible, as will be explained below.

Throughout the 20th century, the significance of sub-spontaneous palm groves regarding palm oil production has declined in favour of plantations. Commercialisation of palm kernels stopped while marketing of palm oil increased both at industrial and small-scale level. That resulted in changes in the landscape, with an extension of plantations not only along swamps but also towards uplands. The first plantations, created during the seventies, are now ageing. Moreover, farmers never had access to improved planting material, which has led to observed disparities between plantations in terms of yield and oil quality.

Historically, there has never been an industrial company exploiting oil palms in the Bombali district and considering environmental factors, the probability that a company settles in the area in the next decades is low.

b. Cropping systems

In the Bombali district, oil palms can be found in two distinct cropping systems:

- Sub-spontaneous palm groves: they result from the natural vegetation regeneration. People try to preserve these trees, which were not planted, from slash-and-burn.
- Oil palm plantations: Contrary to sub-spontaneous palm groves, oil palm plantations are planted by men. They are more or less dense and wide but can easily be distinguished from wild palm groves as trees are planted in lines and are generally shorter.

The sub-spontaneous palm grove

The sub-spontaneous palm grove is not homogeneous across the district. Depending on areas, the wild grove is more or less dense. Disparities within chiefdoms can be observed due to natural factors (humidity, soils), demographic growth, fertility management (slash-and-burn) and social organisation. Oil palms like open bushland and grow well in wet areas. Wild trees are scattered both in uplands and along swamps, within cropping plots. The palm grove is controlled by the traditional authorities and management rules vary from one village to the other. For instance, in the Loko area the village chief decides when people can start to harvest fruit and from this point, picking is free, without consideration for land ownership. In other parts of Sanda Loko and Sella Limba, landowners also own the fruit from the trees located within their plots and manage them as they see fit.

In areas where there are frequent uncontrolled fires, wild trees have become scarce. Oil palms are located on cropping lands, where people grow annual crops (upland rice, groundnuts, pepper, sesame, etc.) and regularly light fires to clear the land. Oil palm is a fire-resistant species but cannot give fruit after burning. In areas where fallow duration has decreased, the natural regeneration dwindles year after year. However, the decrease of fallow duration is not the only factor to explain the reduction in number of oil palms. The expansion of plantations has also led to a relative disinterest for wild trees. Even if people appreciate Dura fruit to obtain red palm oil, wild trees are tall, hard to climb and the extraction rate of palm oil is low. In general, rural families harvest wild fruit for their own consumption but some young men do it as a business. They climb a large number of trees and then sell fruit by head or heap. Most of the time, plantation owners do not harvest wild fruit except if they want to colour their "masenke oil". In this case, they harvest some bunches and process them with fruit from their gardens.

Owing to the time allotted to carry out this study, we could not investigate the sequence of operations in this cropping system. For more information on annual crops from wild oil palms, one can refer to Palliere (2014).

Figure 3 - Sub-spontaneous palm grove (upland). Source : Abadia (2017)

Figure 4 - Sub-spontaneous palm grove (swamp). Source : Abadia (2017)

Oil palm plantations

To establish a plantation, farmers must own the land and ask permission from the traditional chief. Due to land rights, most plantation owners are males. The few women who own plantations have inherited them. The owner of the plantation has the rights on the production. This is of the utmost importance as women are very much involved in palm oil processing yet they do not control the benefits as they do not own the gardens. Their husbands or brothers will be in charge of the distribution between sale and consumption.

As mentioned in the historical review, the first plantation owners received seedlings from the Rokel Tobacco Company or from Action Aid. They established their gardens near swamps and have now resorted to planting upland due to a lack of space in wet areas. Farmers never had accessed to improved planting material, which results in heterogeneous gardens with variable percentages of Dura, Tenera and Pisifera. In the area, the average density of plantation is 30 feet by 30 feet (9m x 9m) for a total number of 60 trees per acre. The plantation starts giving fruit about 3 to 4 years after installation.

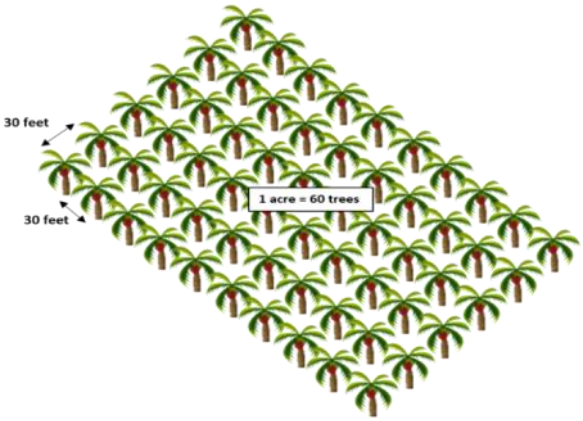


Figure 5 - Average density of plantation. Abadia (2017)

Figure 6 - Oil palm plantation. Abadia (2017)

	Average number of plantations/village	Estimated proportion of plantation owners within the population (%)
Sella Limba[1]	6.1	24.7
Sanda Loko[2]	4.8	19.5
Gbanti Kamaranka[3]	7.3	23.1
Global average	**6**	**22.4**

Table 1 - Estimation on oil palm cultivation in Bombali District. Abadia (2017)

There are **6 plantations** (> 1 acre) per village on average, this number is however only indicative as land tenure and traditional rules vary between villages as explained in the historical review. The proportion of plantation owners within the total population is estimated to be about 22.4%.

No accurate data on the average surface of oil palm plantations in Bombali is available but we have observed different situations, ranging from 1 acre up to 8 acres. In Pujehun, according to data from Gold Tree Company Ltd., the out-growers whom they buy fruit from own an average of 2.47 to 3.70 acres. Considering the significance of this crop in Pujehun district compared to Bombali, we can assume that farmers in Bombali have, on average, smaller plantations than in Pujehun (between 1 and 2.5 acres).

[1] Sample : 8 villages.
[2] Sample : 16 villages.
[3] Sample : 3 villages.

c. Understanding the biology of palm oil and its main by-products

A seasonal production

In West Africa, fruit maturity is highly seasonal. According to data from the FAO, 50% of the production occurs between March and June (table 2). The distribution pattern of oil palm production is comparable in Sierra Leone. The palm oil processing scheme follows this tendency, with a slight delay due to the fermentation stage.

Month	Percentage of production	Seasonal contribution
March	9	50 %
April	12	
May	16	
June	13	
July	8	34 %
August	7	
September	8	
October	11	
November	7	16 %
December	5	
January	3	
February	1	

Table 2 - Monthly distribution pattern of oil palm production in Central and West Africa. FAO (2002)

Pam oil trees' varieties and types of fruit

The fructification of oil palm trees begins between 2.5 and 4 years after plantation and normal production starts between 5 and 7 years after plantation depending on environmental conditions (Jacquemard & al., 2011). Oil palm trees are cross-pollinated, which results in three different types of fruit (varieties) according to the thickness of the endocarp[4]:

- Dura: Fruits have a thick shell, little flesh and a big kernel.
- Pisifera: Fruits are small and without shell. Most Pisifera trees are sterile females so they do not give fruit at all.
- Tenera: Fruits have a thin endocarp, lots of flesh and a small kernel. This variety results from the cross-breeding of Dura and Pisifera.

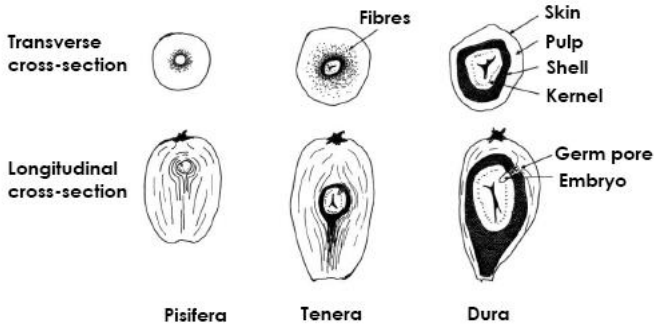


Figure 7 - Comparison of E.guineensis types of fruit. Source : Jacquemard (1998)

Figure 8 - Different types of oil palm fruit Source : Abadia (2017)

The main pollinators are weevils, a type of beetles, of the genus *Elaeidobius spp*., so it is difficult to control the pollination. In the sub-spontaneous palm groves of Africa, Dura is the most widespread type with a frequency of 97% while Tenera is present at a rate of 2.5% (Cochard et al., 2001). Pisifera is almost absent with a rate below 0.5%.

[4] The inside layer of the pericarp (or fruit), which directly surrounds the seeds

In plantations, the proportion of Dura, Tenera and Pisifera varies according to the origin of the trees but the rate of Tenera and Pisifera can be estimated to be higher than in natural palm groves. Crossbreeding of these different types results in different proportions in the F2 generation.

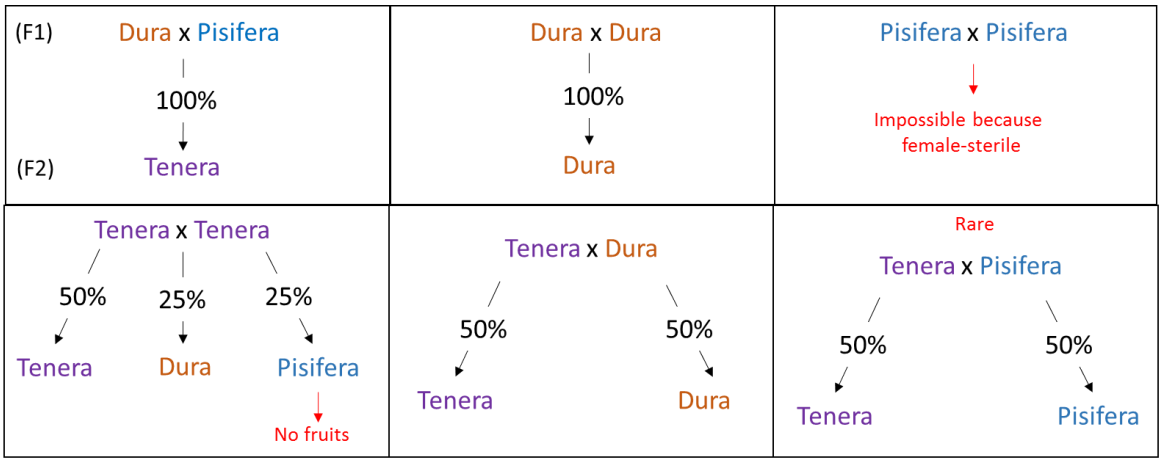


Figure 9 - Genetics of the oil palm. Abadia (2017)

Producers are clearly able to distinguish and describe the different kinds of fruit they harvest from their plantations and wild trees. Those differences are highly significant for them because according to the type of fruit they process, they will obtain different kinds of palm oil that are more or less appreciated by consumers. This has a major influence on selling prices (see section "f. Palm oil: A highly marketable local product."). Tenera fruit contain more oil than Dura. Dura has an extraction rate of 16–18%, whereas it ranges from 22 to 30% for Tenera (Woittieza & al., 2016).

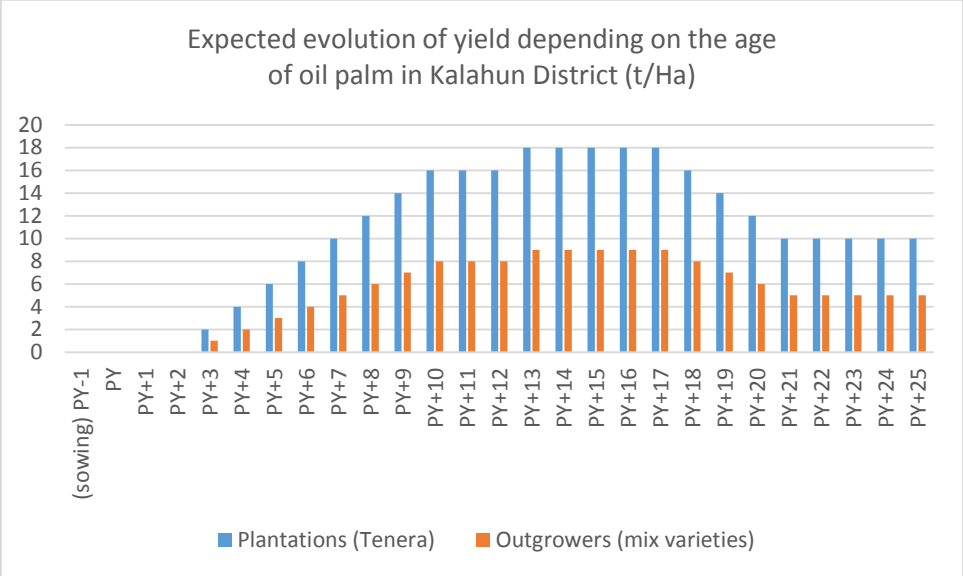


Figure 10 - Estimation from Gold Tree concerning yield from their plantations with improved seedlings (Tenera). Source : Gold Tree (Data is divided by two to obtain the yield of out-growers as they have mixed varieties).

Agro-industrial companies only plant Tenera in order to optimize the extraction rate. It will be shown that in the northern part of Bombali, farmers never had access to improved varieties, so the yield of plantations varies according to the proportion of types and age of trees.

Oil palm products

Palm oil is the main commercial product but local populations use it daily and in several ways:

✔ **Crude palm oil (CPO):** this is the oil extracted from the fruit flesh. As one of the main sources of lipids in food, it is the most valuable oil palm product. Depending on the variety, there are different kinds of palm oil, resulting in different prices:

- "red palm oil": it is the local population's favourite oil. This oil is extracted from Dura fruit. It is deep red in colour and has a sweet taste. . Red palm oil is the richest dietary source of beta-carotene, a precursor of vitamin A, which is an essential nutrient to prevent night blindness and promote growth. In developing countries, vitamin A deficiency is a major problem among both adults and children and palm oil is a good preventive means (Boateng & al., 2016)
- "masankay oil": this oil is extracted from Tenera fruit. It is red but turns yellow when heated. When stored for some time, it starts to solidify instead of remaining red and fluid and must be boiled again. Masankay is mainly used to make soap.
- "red masankay oil": it is a mix from Tenera, Dura and Pisifera fruit. Blending may be done either during processing (mix of bunches) or before commercialisation (mix of oil). When stored for several weeks, two layers will appear in the container: the yellow layer on top and the red layer below. If the production is intended for commercialisation, the seller will mix it again and usually not inform the consumer about its origin. Well informed buyers say that this oil is clearer than red palm oil but in practice few people are able to distinguish between the two kinds of oil. From a taste point of view, red masankay oil is stickier in the mouth

✔ **Crude palm kernel oil (CPKO):** contrary to CPO, this oil is not extracted from the fruit flesh but from the kernel contained in the nut. CPKO may be used as dietary oil but it is mainly used to make "Africana soap". Palm kernel cake is also used as livestock feed.

✔ **Black soap:** this is a traditional soap used as medicine. Contrary to "Africana soap", black soap is not made from kernel or palm oil but from spikelets that are burnt to ashes and then boiled. When water has evaporated, the blend is pounded and suitable leaves are added to obtain therapeutic effects.

✔ **Leaves:** dry leaves are used for light construction (fences, toilets, roofs) and as firewood and **tree trunk** can be used to build bridges in rural areas.

✔ **Palm wine:** palm wine ("poyo" in krio) is produced through the fermentation of sap collected from the flower. A climber puts a container under the flower and the sap drips inside. Villagers only collect palm wine from wild trees because when sap is taken out of the tree, it will no longer give fruit. When extracted, the sap is sweet and non-alcoholic. Fermentation starts quickly and after only two hours, the alcohol content rises up to 4%. Palm wine is consumed during traditional ceremonies and community events.

✔ **Fibres:** fibres are a by-product of palm oil processing. They are used to light fires and for integrated biological control in swamps. Farmers spread them in swamps to attract ants, which repel rats.


Figure 11 - Processed products from palm oil. Abadia (2017) (From left to right : dietary palm oil, palm wine and Africana soap).

d. Traditional cropping practices and workload

Main steps

Few farmers maintain their gardens without employing workforce, as many gardens were created during the eighties and their owners are now growing old. Men are in charge of all cultivation operations, which are physically tough and risky. Pruning and harvesting require skilful workers so people employ young men who "specialize" in those tasks, with the exception of farmers who are healthy and/or have sons. During peak production time, plantation owners struggle to find skilled workforce and access to labour is the main limiting factor of this agricultural activity.

Clearing of brushwood: this is a critical operation to avoid wild fire. The best option is to clear the gardens 4 times a year when trees are young (0 – 5 years). Then, the shade from adult trees prevents weeds from growing quickly, so the frequency for clearing the brushwood can be reduced from 4 to 2 times a year (once in June and once in October). Performing this operation during the rainy season will allow weeds to get rotten and decompose. The land is clear during the dry season and fires will not pass through the garden easily.

To clear their gardens, producers employ "work gangs" (locally called *kune/wangane*). Those groups of men work together in the plot and are paid by the day. Clearing of brushwood is labour intensive and in order to make this work profitable, farmers intercrop oil palm with annual crops (rice, groundnuts, cassava), at least during the first 3 years, while there are a lot of weeds and oil palm roots are still short enough to allow intercropping.

Pruning: This is the removal of non–functional leaves (old, dried or diseased leaves) from the palm. It is necessary to remove them in order to facilitate the detection of ripe bunches and access to fruit during harvesting time. Farmers need to hire workforce for this task, so they do it according to their funds and the health of trees. It may be every second or third year, depending on whether the pruning has been well done when harvesting.

Trimming: The removal of fern and other plants from the palm tree. This will facilitate climbing for harvesting and makes the palm tidy. It also prevents pests from hosting in the palm. It enables farmers to determine the number of ripe fruit bunches from afar. Trimming can be done as and when necessary

Harvesting: oil palms give fruit year-round but the main part of the production is concentrated during the dry season, between March and June. Most of the time, farmers hire people for this task, except if their sons can manage by themselves. They climb trees using ropes woven with raffia palm. They first remove branches which prevent access to fruit by using a machete. Then, they cut bunches which fall down to the ground. Even if oil palms produce fruit all year, climbers generally refuse to climb during the rainy season because trunks are slippery so it is dangerous. One man can climb 20 to 30 trees per day but the harvest will take place little by little, according to the workforce available for processing.

After harvesting, fruit are transported and gathered before processing but this step is considered as a "process preparation step" (see section "e" on the processing).

Task	Months	MD (man-days)	Family workforce (MD)	Hired workforce (MD)	Cost of hired workforce / day
Clearing of brushwood	June - July ; October - November	20	10	10	10 000
Pruning	January - May	3	-	3	24 000
Harvesting	January - June ; October - December	4	-	4	30 000
Total MD/acre		**27**	10	17	
Total MD/drum of raw fruit		**3.5**			

Table 3 – General distribution of workforce in oil palm plantations. Abadia (2017)(This data is indicative and may vary from one household to another according to the availability of family workforce)

Intercropping

Oil palm has a complicated root system and a wide canopy, so possibilities for intercropping are limited to the first 3 years (Jacquemard, 1998). In Bombali, farmers intercrop oil palm with groundnuts, cassava or upland rice during the first years. They then grow some pineapples more or less densely and keep scattered fruit trees (mango, kola nut).

Yield

The average plantation density being 60 trees/acre, it can be estimated that each tree produces 4 bunches annually, for a total of 240 bunches/acre/year. According to the type of tree, a bunch can weigh between 10 to 50 kg (FAO, n.d; Jacquemard, 1998). In the Bombali district a bunch can be estimated to weigh 11 kg on average. Thus, in Bombali, one acre of plantation produces **2.6 t of raw fruit (= 5.4 t/ha)** on average. As mentioned above, plantations include different types of fruit (Tenera, Dura, Pisifera). "Heavy bunches" therefore does not always mean "high yield" because Dura fruit have big kernels but not much flesh compared to Tenera fruit. The extraction rate may vary according to the proportion of Dura and Tenera bunches processed. However, in Bombali weight is a criterion to determine the selling price of raw fruit. According to its size, a bunch coming from a plantation is sold between 2,000 and 10,000 Le (compared with 1,000 Le for a bunch from a wild tree). The average price can be assessed at 3,000 Le/bunch.

Economic value

To evaluate the economic value of the plantation, the "gross value added" (GVA) is used. It can be defined as the value of output less the value of intermediate consumption" (OECD, 2001). The plantation density is 60 trees/acre and each tree is estimated to produce 4 bunches annually, for a total of 240 bunches/acre/year. Nevertheless, the market for raw fruit is limited due to the absence of wholesalers and the highly perishable nature of the product. The only buyers are villagers who want to process fruit for their own consumption or small businesses. However, they prefer to buy wild fruit, which are cheaper (1,000 Le/bunch). Consequently, it is not possible to sell the entire production of 1 acre and the maximum sales potential is about 50 bunches/acre. The major part of the production will be processed by farmers themselves (and their relatives).

Oil palm tree cultivation does not require inputs: farmers grow their fruit in recycled water sachets and plant them without using fertilizers or manure. It can therefore be considered that there are no direct costs.

Sales			
Product	Quantity	Unit Price (Le)	Total (Le)
Bunches	50	3,000	150,000
Direct costs			
Direct Costs			0
Gross Value Added			
GVA / acre (Le)			150,000
GVA / MD (Le)			5,555

Table 4 - GVA created by selling fruit from 1 acre of plantation. Abadia (2017) - – 1 euro = 8500 Le

The average profit is about 150,000 Le/acre and work productivity 5,555 Le/day (1 euro = 8,500 Le).

The two cropping systems are complementary. Wild trees are a source of Dura fruit, highly appreciated for red palm oil while plantations allow farmers to get better yield. Farmers never had access to selected planting material but even if yield is low (5.4 t/ha against 8t/ha in the Kalahun district (see figure 10), oil palm cultivation is increasing. This dynamic is linked with market opportunities, due to a growth of non-farming population and opening up of the area thanks to better road infrastructure.

e. Transformation: the traditional "mortar and pestle" processing technique

In Sella Limba, Sanda Loko and Gbanti Kamaranka, women are in charge of processing palm fruit into oil. To do so, they use rudimentary tools: a wooden mortar and pestle, some pots and a local sieve. This technique has been almost abandoned in the southern part of Sierra Leone where farmers have larger gardens and process bigger quantities of palm oil. This technique does not require considerable investments but it is labour intensive. It is adapted to processing small quantities of fruit, for instance a few bunches of wild fruit, but not to processing fruit from large plantations.

Transport, fermentation and threshing

Men are in charge of harvesting and transporting bunches to the fermentation site. They split bunches one by one with a small axe, gather the fruit in a heap and cover them with palm leaves for 2 to 4 days. Fermentation allows the fruit base to come off the spikelet, facilitating threshing. Nevertheless, this practice also increases the rate of FFA (free fat acids): the storage periods of raw fruit and processed palm oil both lead to a high microbial load which brings about oil hydrolysis and FFA generation (Tagoe & al., 2012).

After the fermentation step, women and children are in charge of threshing the fruit. They take off spikelets by hand. Most of the time, the family workforce is in charge of this task. Transport, fermentation and threshing are the process preparation steps.

Figure 12 - Splitting of fruit before fermentation. Source : Abadia (2017)

Figure 13 - Threshing of fruit after fermentation. Source : Abadia (2017)

Processing steps

Women usually process one pot of fruit at a time. The day before processing, fruit are poured into a big pot, water is added and they are boiled during two hours. They are then let to cool during the night and processing starts early the next morning. Little by little, boiled fruit are transferred into the mortar and crushed with a pestle. Then, the fruit are divided into two pots and water is added. They are washed and fibres and kernels are removed by using local sieves (those by-products will be used later, to extract other oils). The pots are placed on the fire again to evaporate the remaining water.

The remaining fibres are put into a small hole dug in the ground, covered with leaves and left to ferment for two days. They are then boiled again (1 hour) to release the remaining oil trapped inside and wrung with a "rope press" (sometimes with the help of a man). This structure is made of wood and local ropes (or used mosquito nets). Then, the mixture is boiled again to remove water.

Some women repeat this process twice. The oil obtained with this method is not suitable for consumption. People use it to make soap.

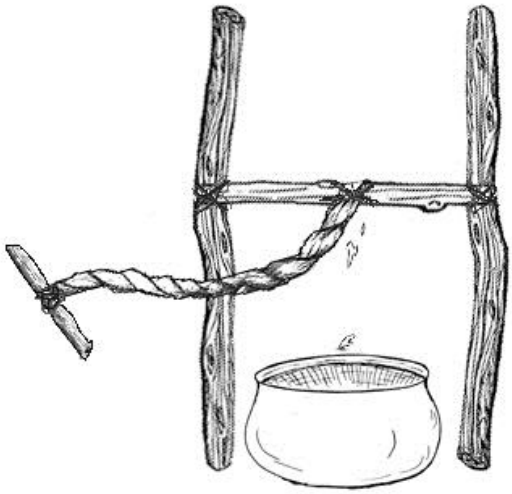


Figure 14 - Drawing of local rope press. Abadia (2017)

Nuts will be kept for a few more days or weeks to properly dry before being cracked and turned into CPKO, locally known as "nut oil".

For the "mortar and pestle" process, women use local pots but in order to compare this technique with the "palm oil pit technique" we will express the yield data by drum, which is equivalent to three big local pots. With the mortar and pestle technique, the yield is around **6 gallons of palm oil/drum**, according to the fruit variety (Dura fruit give less oil than Tenera).

Figure 15 - Traditional palm oil processing steps. Abadia (2017) (from left to right: crushing within a mortar; washing of fibres; squeezing with a local rope press).

Task	Family workforce (MD)	Hired Workforce (MD)	Total workforce (MD)
Transport + threshing	4	-	4
Processing	4.5	12	16.5
Total MD/drum	**8.5**	**12**	**20.5**

Table 5 – General distribution of workforce with traditional process. Abadia (2017)

(This data is indicative and may vary from one household to another according to the availability of family workforce)

Crude palm kernel oil processing

The process of turning kernels into oil is a time-consuming task often given to elder, inactive women or children. After drying the nuts several days, the first step consists in cracking nuts one by one with a stone to extract kernels. Kernels are then roasted in a pan for about half an hour. Finally, the oil is filtered, marking the end of the process. Soda and water are then added to make "Africana soap".

A second option consists in stopping the roasting after a few minutes and pounding the kernels into a mortar. In this case, water is added and oil is skimmed like for palm oil processing. This option takes more time but the oil is clearer and consumers prefer it for food.

With one drum of raw fruit, 3 gallons of CPKO can be obtained. The process will take about 6 MD.

Task	Family workforce (MD)	Hired workforce (MD)	Total workforce
Cracking	4	-	4
Processing	2	-	2
Total MD/drum of raw fruit	**6**	**-**	**6**

Table 6 - General distribution of workforce for CPKO processing. Abadia (2017)

(This data is indicative and may vary from one household to another according to the availability of family workforce)

Figure 16 - Steps of CPKO processing. Abadia (2017)

f. Palm oil: A highly marketable local product

In Bombali, the main part of the production is sold on local markets. Some wholesalers come to purchase containers and sell them in Makeni but it is still a regional market. Up to now, the production is not exported outside the District.

As mentioned earlier, oil palm gardens are usually owned by men. Even if women are in charge of palm oil processing, men control the production and sale. They decide the quantities to sell and to keep, the selling prices and the way the family will spend the earned money.
Palm oil is sold in two different packaging types:

- Pint (= 33 cl)
- Container (= 5 gallons = 22.5 l = 68 pints)

Men handle the wholesale trade (by container) while women manage the retail trade (by pint).

Market prices

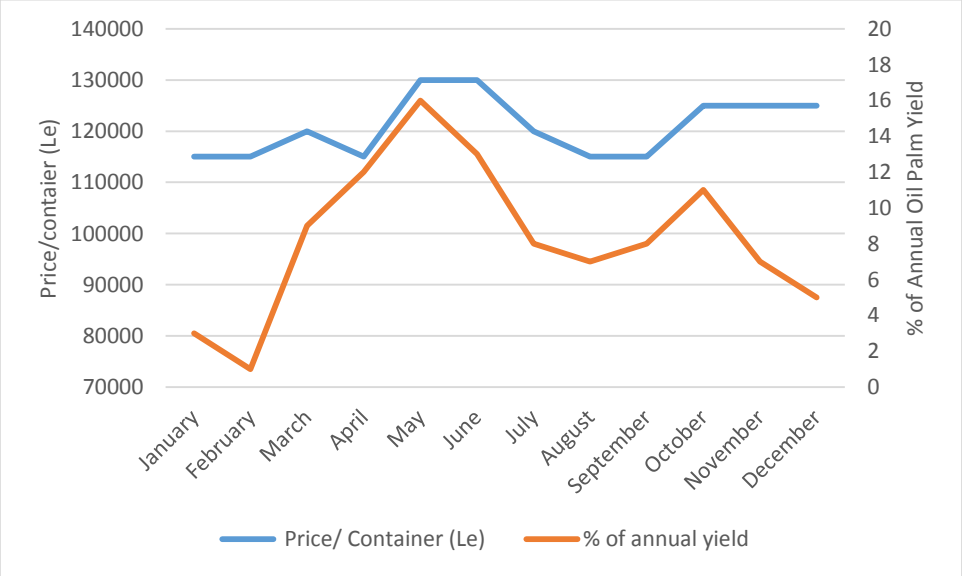


Figure 17 - Monthly evolution of palm oil price and distribution pattern of oil palm production. Abadia (2017)
Palm oil price data were collected in Kamakwie market between 2012 and 2015. The distribution pattern of oil palm production in West Africa comes from FAO (2002).

As mentioned at the beginning of this document, palm oil production varies along the year. Prices vary according to supply and demand: when production is low, prices are high and when production is high, prices are low. Nevertheless, it can be observed that the price graph follows the same pattern as the production graph (figure 18) whereas both graphs should theoretically have opposite shapes. That can be explained in several ways. Firstly, palm oil is a processed product and, as described above, processing takes time: the oil is not directly sold when fruit production is high. Secondly, there is a high level of household consumption of palm oil and the first production is kept for domestic use. This also explains the delay between production and sale. Finally, palm oil is a product that can be stored and speculated on. After the production peak (April-May-June), prices will fall because most households cannot wait to sell. They will increase again in the autumn because only few people are able to keep their oil till then to commercialize it and obtain good prices. They will finally decrease a little bit from February onwards because producers sell their production before the next harvest. Prices also increase on the specific occasions of religious events (Ramadan and Christmas).

Price variations are less significant on the retail market than on the wholesale market. In Kamakwie, a pint of palm oil costs about 2,000 Le. Prices will fall on the retail market during the production peak, but not on the wholesale market. There are several factors to explain this phenomenon. Firstly, the decrease of retail market prices is linked with a strong competition between retailers. It is also due to the simultaneous production peak of wild trees and the better availability of "red palm oil". Prices do not decrease on the wholesale market because in the event of low prices, producers still have the alternative of sending their wives to sell directly on the retail market.

Palm oil is highly marketable and producers do not encounter problems to sell their oil. They exploit both the wholesale and the retail markets and thanks to this strategy, they keep a high negotiation power against wholesalers.

Month	Price/container (wholesale market)	Price/pint (retail market)	Retailer's margin per container
January	115,000	2,000	21,000
February	115,000	2,000	21,000
March	120,000	1,900	9,200
April	115,000	1,800	7,400
May	130,000	2,000	6,000
June	130,000	2,000	6,000
July	120,000	1,900	9,200
August	115,000	1,800	7,400
September	115,000	1,900	14,200
October	125,000	2,000	11,000
November	125,000	2,000	11,000
December	125,000	2,000	11,000

Table 7 - Selling prices (Le) on wholesale and retail markets (Kamakwie). Inter Aide (nd) – 1 euro = 8,500 Le

As a conclusion to this market analysis, it can be observed that prices of Crude Palm Oil and Crude Palm Kernel Oil are linked. CPKO is always cheaper than CPO. Red palm oil is usually more expensive than red masankay.

CPO (red palm oil)	CPO (red masankay oil)	CPKO (nut oil)
2,000	1,500	1,000

Table 8 - Palm oil and palmist oil selling prices on Kamakwie market (Le) (May 2017).

Fruit marketing

When farmers lack workforce to process their fruit, they sell some bunches to women in the village who do not have oil palm gardens. Some young men also harvest wild fruit and sell them in the villages. Those women will process fruit into oil for their own consumption. There is no wholesale market for oil palm fruit because there are no industrial mills in the area. Each customer will negotiate the price according to the bunch size, the variety and the quantity. Dura fruit are smaller, the extraction rate is lower than with improved fruit and their production cost is zero so they are cheaper.

Women generally prefer to buy wild fruit for red palm oil because kernels are bigger and contain more kernel oil.

Type of bunches	Unit price	Quantity to fill 1 drum	Price/drum of raw fruit
Dura	1,000	40	40,000
Tenera	3,000	30	90,000

Table 9 - Selling prices of bunches according to fruit types in Bombali District. Abadia (2017)

Impending challenges

Palm oil is a staple food product that the local population highly appreciates. Prices reflect the qualities, which are intended for different consumers. Selling prices of red palm oil are higher due to its well-known quality (taste and colour). It is intended for middle and high classes or is consumed during special events (funerals, birth) while people are more and more inclined to consume "red masankay oil", a mix between red palm oil and masankay oil. The market for red masankay oil is developing thanks to a lower price and changes in consumption habits. It is a good way of enhancing the value of oil palm plantations while responding to consumers' preferences concerning colour. CPKO and masankay are cheaper and aimed at another market: the local soap industry.

Due to the poor condition of the road between Makeni and Kamakwie, the local market is still preserved. On the one hand, producers cannot easily sell their oil to Makeni so the product is still highly available locally. On the other hand, the local market is preserved from the competition of imported oil so that producers may obtain good prices. In coming years, the challenge will be to keep this competitiveness when faced with imported oils. Farmers will need to reduce their costs, through improvement of yield (access to Tenera), increase of extraction rate (better processing techniques) and value creation through usage of by-products (CPKO, cattle feeding). It will also be essential to preserve Dura trees to compete with imported oil by promoting local quality (and for environmental concerns). This is a regional challenge and Guinea, where production is increasing through the development of Tenera plantations, is facing the same issues (Ferrand & al., 2012).