Chapter

Congo: The Next Frontier for the Palm Oil Industry

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Abstract

The oil palm (*Elaeis guineensis* Jacq.) originated in West and Central Africa. Some of the earliest scientific breakthroughs that led to the development of the palm oil industry were made in the Democratic Republic of Congo (DRC, earlier known as the Belgian Congo); these include the elucidation of the genetics of the kernel shell thickness and the identification of the basic engineering principles for palm oil extraction. In the past 50 years, Indonesia and Malaysia rapidly expanded palm oil production to account today for over 80% of the world palm oil supply. This accelerated development has significantly contributed to the socioeconomic development of those two countries, but has raised concerns regarding environmental sustainability. Current level of knowledge makes it possible to mitigate the negative impact of palm oil on the environment and to achieve Net-Zero Emission targets. The palm oil industry has proven its ability to lift millions of people out of poverty. With plentiful suitable land, diverse oil palm genetic resources, abundant labor, large palm oil local and regional markets, and commitment to sustainable palm oil sector, the DRC should become the next frontier for palm oil and chart the course for responsible development of a palm oil industry that contributes to human prosperity, social progress, and environmental protection.

Keywords: *Elaeis guineensis*, palm oil, sustainability, net-zero emissions, Democratic Republic of Congo

1. Introduction

The oil palm (*Elaeis guineensis* Jacq.) originated in the rain forest of West and Central Africa but is now commercially grown throughout the tropical belt, with a high concentration in Southeast Asia. It arrived in South America in the 16th century but did not reach Asia until the middle of the 19th century [1]. It is in Southeast Asia that, in the second half of the 20th century, the growing of oil palm on a commercial scale for oil production developed rapidly; Indonesia and Malaysia today produce 87% of the global output of palm oil. In just fifty years, between 1970 and 2020, the world combined production of oil from the oil palm increased over 37-fold, from 2.31 million metric tons in 1970–87.32 million metric tons in 2020. The market share of palm oil relative to the other vegetable oils grew from 17% in 1970 to 42% in 2020 [2].

Palm oil is today found in nearly 60% of all packaged products in supermarkets because of its versatility and low cost relative to the other vegetable oils. In its refined form, palm oil is used as an ingredient in a wide range of foods, such as margarine, confectionery, chocolate, ice cream and bakery products where it contributes taste and texture [3]. Palm oil is also used in a variety of non-food applications including soaps and detergents, cosmetics, pharmaceuticals, and biofuels. Due to its versatility, and because the oil palm produces about ten times more oil per hectare of land than any other oilseed crop, demand for palm oil will continue to rise in the foreseeable future. The global palm oil market size, which was valued at USD 62.94 billion in 2021, is projected to reach USD 99.41 billion by 2030, a compounded annual growth rate (CAGR) of 5.21% for the period [4]. According to Afriyanti et al. [5], the world demand for cooking oil and biodiesel by 2050 could rise to between 264–447 million metric tons of which Indonesia could provide 39–60%. Other palm oil producing countries are expected to fill the remaining gap.

The rapid expansion of the palm oil industry, particularly in Malaysia and Indonesia, has generated mixed results; while it has been associated with perceived negative social and environmental impacts, it has led to positive benefits, including large fiscal revenues for producing countries and significant regular income streams that have taken out of poverty millions of smallholder growers involved in oil palm cultivation [6, 7].

In the past ten years, countries in South America have been rapidly expanding their acreage under oil palm while avoiding deforestation and guided by roundtable certification programs [8, 9]. With the current body of knowledge, plans are being developed to enable continued expansion of oil palm cultivation to 2050 in Indonesia and Malaysia without deforestation and on peat-free land [4, 10, 11].

This chapter submits that the next frontier for the growth of the palm oil industry is in Africa, and particularly in the Democratic Republic of Congo (DRC) where abundance of land, unique and diverse oil palm genetic resources, suitable weather, cheap labor, access to a large consumer base make it possible for this country to become a significant contributor to meeting the growing demand for palm oil. This can be achieved while contributing to the global effort of achieving the Net-Zero Emissions target [12–14]. The chapter gives a brief history of palm oil production and trade, describes the early discoveries made in Congo that led to the establishment of the palm oil industry in the world, and discusses lessons learned from the expansion of palm oil in Asia and Latin America that could be utilized to chart the course of a new development of the palm oil industry in a way that contributes to human prosperity, social progress and environmental protection.

2. Brief history of palm oil

The rain forest of West and Central Africa is the center of origin of the oil palm (*Elaeis guineensis*). Its fruits were taken to other parts of the world between the 14th and 19th centuries. Palm oil (PO), extracted from the mesocarp of the oil palm fruit, and palm kernel oil (PKO) that is expressed from the fruit endocarp inside the kernel have been used for food, cosmetic and therapeutic applications in Africa for thousands of years. Wild and semi-wild groves of oil palm are found in the humid belt of Africa, from the coastal areas of West Africa to the Congo basin in Central Africa [1].

There is archaeological evidence that palm oil was taken to as far as Egypt since a mass of several kilograms of it was found in the excavation of an early tomb dated to 3000 B.C. [15]. It is at the beginning of the 20th century that commercial scale planting of oil palm started mainly to supply the production of soap and margarine in Europe [16]. In 1911, Sir William Leverhulme, founder of the Lever Brothers company, arrived in Congo with an authorization from the Belgian Minister of Colonies to develop the palm oil business with access to a concession of about 750,000 ha[17]. The company he founded, *Huileries du Congo Belge*, is still in operation in the palm oil business today, although under a different name, *Plantations et Huileries du Congo*. Such a large concession was given to Leverhulme with a mandate to study the rational utilization of wild palm groves and find the technical basis for establishing plantations; to study the extraction methods for palm oil and the handling of palm kernels; to study appropriate transport and storage methods for palm products and to identify markets and industrial outlets for palm products [18]. In 1910, Congo exported 2160 tons of palm oil and 6140 tons of palm kernels. By 1957, the volume of export of palm oil had grown to 150,000 tons [19].

In Indonesia, the first commercial scale planting of oil palm is said to have been introduced by Adrien Hallet [20], a Belgian national who acquired the knowledge of planting oil palm in Congo [18, 21]. In 1911, Hallet established a plantation in Sumatra using seedlings obtained from the Buitenzorg (now Bogor) Botanical Garden. In Malaysia, Henri Fauconnier is credited with starting the first true oil palm plantation in 1917 at Tennamaran Estate in Batang Berjuntai, Selangor [22]. In the 1960s, the Malaysian government promoted the cultivation of oil palm through the agricultural diversification programme to reduce the country's dependence on rubber and tin, and to alleviate rural poverty [23]. The palm oil industry in Malaysia is credited with consistently contributing toward poverty eradication and narrowing the income gap between rural and urban residents [24, 25]. Palm oil has been shown to contribute to the sustainable development goals (SDG) more than any other vegetable oil [26].

In 2022/2023, global production of palm oil was estimated at 76 million metric tons, a 4% increase over the 73 million produced in 2020/2021 [27]. Although world trade of palm oil started with production from Africa in the late 19th century, today Indonesia and Malaysia account for over 83% of the total production while the African production has been reduced to a mere 4% [28].

3. Early days of the palm oil trade

In Africa, wild or semi-wild groves of oil palm have been used for thousands of years to produce oil for food, cosmetic and therapeutic uses [16]. There is archeological evidence that palm oil was traded as early as 3000 years ago, as several kilograms of it were found inside an ancient tomb in Egypt [1, 15]. Palm oil is reported to have been exported from West Africa to England as early as in 1790 [1]. But it is in the 1850s that the trade of palm oil between Africa and Europe developed, mainly to support the production of soap in England [29]. By 1870, up to 30,000 metric tons of palm oil extracted from the fruits of oil palms growing in wild and semi-wild groves were being exported to England from British colonies in West Africa. Palm kernels were also being exported in even larger quantities [30] for use in soap manufacturing and candle making. Palm kernel oil was preferred in those applications because the lather produced from it was more satisfying, and the candles were odorless upon burning. Palm oil was also perfectly suited to use as an industrial lubricant, for oiling engine parts and in tinplate production [29].

In Congo, export of palm oil and palm kernel started in the 19th century. In 1910, it was recorded that 2160 tons of palm oil and 6140 tons of palm kernel were exported to Europe, mainly England for the oil and Germany for the kernel [19, 31]. By 1960, the export of palm oil had risen to 167,000 tons, making palm oil export from Congo second only to Nigeria and ahead of Malaysia and Indonesia [18, 19]. While Congo produced 224,000 tons of palm oil in 1961, Malaysia and Indonesia produced 94,846 tons and 145,700 tons respectively. Sixty years later, Congo's production was stagnating at 300,000 tons, while Malaysia's and Indonesia's production had exponentially grown to 19.1 million tons and 44.8 million tons respectively. The next section shows that the technological bases of the palm oil industry were laid in Congo. However, those innovations did not benefit Congo or African producing countries. Instead, cooperation and competition between two different clusters in former colonial territories enabled the rise of palm oil as a global commodity in Southeast Asia, mainly in Indonesia and Malaysia [29].

4. Technological foundations of the oil palm industry

4.1 Genetic control of the *Tenera* phenotype

Some of the earliest scientific breakthroughs that led to the development of the palm oil industry were made in the Democratic Republic of Congo (earlier known as the Belgian Congo). These include the elucidation of the genetic basis of an important trait in *Elaeis guineensis*: kernel shell thickness. Fruits of the oil palm have kernels that may have a thick shell, a thin shell or no shell at all. Oil palm geneticists have called the palms with large kernel and thick shell the *Dura* form, the ones with small kernel and thin shell are called the *Tenera* form and, the palms without kernel shell are the *Pisifera* form [1]. Fruits of palms of the *Tenera* form contain more oil than those of the *Dura* form since in the *Tenera* form, the mesocarp represents 55–96% of the fruit, while the mesocarp in the Dura form only represent 35–65% of the fruit.

Genetic studies undertaken in the 1930s at the INEAC (*Institut d'Etudes Agronomiques du Congo*) research station located at Yangambi by Beirnaert and Vanderweyen [32] revealed that the kernel shell thickness was controlled by a single gene with two codominant alleles. The genome of palms of the *Dura* form carries two sh+ alleles, while palms of the *Pisifera* type carries two sh- alleles. The *Tenera* form was identified as a hybrid between the Dura and Pisifera forms as it carries one sh+ allele and one sh- allele. As early as 1946, Vanderweyen was able to demonstrate that by crossing *Dura* and *Pisifera* forms (called DxP cross), one could obtain 100% *Tenera* progenies [33, 34]. Crosses between two *Tenera* gave progenies that segregated according to Mendel's heredity law into 25% *Dura* form, 25% *Pisifera* form and 50% *Tenera* form. This was called the "Congo theory" and it was later confirmed in Nigeria [35] and in Malaysia [36]. The DxP cross has become the norm today for producing *Tenera* seedlings for planting in all commercial oil palm plantations and constitute an important basis for the genetic improvement of oil palm productivity [37].

4.2 Engineering principles of palm oil extraction

Another scientific achievement that greatly contributed to the growth of the palm oil industry and trade was the establishment of the basic engineering principles of the palm oil extraction process that were published in 1955 in the Mongana Report [38]. The Association of producers and exporters of oil palm of Belgian Congo,

known under their French acronym CONGOPALM, set up a pilot plant at Mongana in DR Congo to investigate in detail the scientific, engineering and technoeconomic principles of processing oil palm fresh fruit bunches (FFB) into industrial grade palm oil. Their investigations were conducted between 1952 and 1955. Their findings were published in what is known today by all palm oil mill engineers as the "Mongana Report" [38, 39]. Over sixty years after it was published, the Mongana report continues to guide the design and operation of palm oil mills around the world [40].

5. Growth of the palm oil industry

In the second half of the 20th century, the development of the palm oil industry received a very strong impetus, mainly from Malaysia and Indonesia. Between 1960 and 2010, global palm oil production has almost doubled every ten years, thanks to the output from these two countries [41]. Such an achievement does not come about by chance. In 1956, the Malaysian government established the Federal Land Development Authority (FELDA) with the objective of poverty eradication through the cultivation of oil palm and rubber [42, 43]. The authority oversaw land development and allocation to settlers, facilitating access to finance by planters, as well as implementing downstream projects covering the entire crop value chain and generating its own income through a variety of businesses and corporate entities such as the FELDA Holding Berhad, Felda Plantation Sdn Bhd and Felda Global Ventures (FGV).

In Indonesia, between 1967 and 1997, palm oil production increased 20-fold [44]. Although support to plantation agriculture was included in Indonesia's development plans since the 1950s, it is only in the late 1970s that sustained efforts were applied with the Nucleus Estate Scheme (NES) (*Perkebunan Inti Rakyat*; PIR), whereby state-owned plantation companies (the 'nucleus') helped smallholder farmers (namely plasma farmers) to grow oil palm [45]. Support to the palm oil industry came in three phases. First there was direct involvement of the government with state-owned companies having access to land and to institutional support. The scheme was implemented at the same time as a transmigration program. The state-owned nucleus estate held 20% of the land, while the relocated smallholders were allocated 80% of the land and received with technical assistance from the nucleus estate. This so-called PIR-trans phase lasted from 1986 to 1994. In a second phase, In the second phase called KKPA (*Koperasi Kredit Primer untuk Anggota*; Primary Cooperative Credit for Members) between 1995 and 1998, the door was opened to foreign direct investment in large scale plantations but following the private-community partnership model tested in the PIR-Trans phase. After 1998, the Indonesian government shifted to a liberalization policy based on decentralization and encouraging public–private partnerships between market actors and the government, and social–private partnerships between market actors and smallholder communities but following a market-driven model [45]. Between 1970 and 2000, Malaysia and Indonesia have experienced economic growth and structural changes that have brought with them rural poverty reduction and improved living standards, all linked to, among other things, the growth of the palm oil industry [46, 47].

While the palm oil industry was growing and contributing to social and economic development of Malaysia and Indonesia, technical collaboration on oil palm plantation technology was on-going between palm oil producing countries of Southeast Asia and Africa [29, 48]. Several private companies were involved in the oil palm business in both clusters of producing countries. The main difference was government policies and support. In Congo, for instance, the government of the then Republic

of Zaire nationalized all foreign owned businesses, including farms and plantations [49]. Nationalized businesses were handed over to local citizens to manage. Many of them, including oil palm plantations collapsed and never recovered. Fifty years later, the missed opportunities have become evident to policy makers and to potential investors. In April 2023, the government of the DRC established the *Conseil consultatif présidentiel pour le pacte national de l'agriculture et de l'alimentation* (CCP-PNAA; Presidential Consulative Counci for the Food and Agriculture National Compact) which will be tasked with, among other things, designing and recommending policies to facilitate private investments in agriculture [50].

6. Opportunities for the DR Congo

6.1 Increasing demand for vegetable oils

The global vegetable oil market is expected to grow in value at over 7% per year from USD 318 billion in 2022 to reach USD 791 billion by 2031, with the palm oil segment being the biggest contributor to this growth [4]. Demand for vegetable oils over the past two decades has been driven by a combination of population growth, changing dietary patterns, economic development, and evolving consumer preferences. The specific trends and types of vegetable oils in demand may vary by region and market, but overall, this increase in demand has made vegetable oils a crucial component of modern diets and industries, and is expected to continue.

Palm oil has evolved to become one of the most widely consumed and traded vegetable oils globally, with its demand driven by its cost efficiency, versatility, and suitability for a wide range of products and applications. It is estimated that more than half of all packaged products consumed in the USA, including lipstick, soaps, detergents and even ice cream, contain palm oil [51]. The market share of palm oil compared to the other vegetable oils has steadily grown from 13.6% in 1961 to 36.5% in 2020 [2]. Palm oil is now the most traded vegetable oil in the world. The very high productivity of oil palm in terms of quantity of oil produced per hectare of land, which is five to ten times the productivity of other oilseed crops, gives palm oil a major role in meeting the demand for vegetable oil while maintaining a low ecological footprint. Environmental concerns have been raised regarding the rapid expansion of oil palm cultivation in Malaysia and Indonesia [52, 53]. While these countries are taking steps to address those issues, other palm oil producing countries, such as DRC, have a clear opportunity to contribute to meeting this growing demand.

6.2 Abundant and suitable land, favorable weather

With 2.345 million square kilometers, the DRC is the second largest country in Africa after Algeria. Development agencies estimate that the country has over 80 million hectares of arable land, of which less than 10% is currently under cultivation [54, 55]. This figure concerns general agriculture and has always been used by the Ministry of Agriculture. In 2019, a team of researchers assessed the available land suitable for growing oil palm in the Congo Basin, of which 60% is contained in the DRC. Their data suggest that up to 280 million hectares could be suitable for oil palm cultivation in the Congo Basin, including 167 million hectares in the DRC alone [56]. The model used to calculate this land does not include primary forest. In fact, of the total suitable area available in DRC, only 13% is found in protected areas, meaning

that 145 million hectares are found in areas that are compatible with current environmental standards such as the Roundtable on Sustainable Palm Oil [57].

It should be noted here that DRC and other African countries of West and Central Africa signed the Marrakech Declaration in November 2016 during COP-22 committing themselves to sustainable development of the palm oil value chain with the support of the private sector and civil society organizations in what is known as the African Palm Oil Initiative [58]. These countries support the development of oil palm plantations but with a commitment to zero-deforestation. The Ministry of Agriculture in the DRC has targeted over 2000 farms and plantations abandoned since the 1973 nationalization for immediate development [59]; many of these plantations used to be under oil palm cultivation and could be rapidly be brought back into production.

The climate of the DRC, with mean surface air temperature of 24–28°C and over 1500 mm of rainfall, is well suited to the oil palm cultivation. Straddling the Equator, the rainfall distribution throughout the year is rather uniform with a short dry period that grows longer as one get farther away from the Equator line.

While oil palm development can affect climate change, mainly by increasing carbon emission through deforestation and biodiversity loss, it is also true that climate change will affect the capacity of lands to produce palm oil [60]. It is therefore imperative to think of how the suitability for oil palm cultivation will be affected by climate change. Paterson et al [61] have described the CLIMEX mechanistic niche model which can be used to estimate the evolution of the scenarios of suitable growing areas for oil palm under climate change in Africa. With this CLIMEX tool, Paterson has shown that the highly suitable and suitable areas for growing palm oil between now and 2050 were concentrated in the DRC, with these areas expected to become less suitable after 2050 [62]. However, DRC will remain the region with the highest availability of suitable land for oil palm production.

6.3 Availability of adapted genetic resources

The name "Yangambi" is found in the pedigree of elite oil palm varieties planted in many countries with a well-established palm oil industry [48, 63]. While the origin of the parent material has not been clearly determined, the Yangambi trait is usually associated with high yield [48, 63]. Yangambi is a town in the DRC that was the home of *Institut national pour l'étude agronomique du* Congo *belge (*INEAC) where, in the 1930s-1940s, the relationship between the *Dura*, *Pisifera* and *Tenera* forms of the oil palm was elucidated [1, 32, 33]. Its coordinates are 0.767475°N and 24.441404°E (https://en.wikipedia.org/wiki/Yangambi). The use of this name for the oil palm material suggest that this material originated from the research station. Since DRC occupies a large proportion of the Congo Basin which is part of the center of diversity of the oil palm, it should be expected that material similar to, or even with better performance characteristics than, the Yangambi line that was taken to southeast Asia could be found. The oil palm is found naturally growing in a diversity of microclimates in DRC. An extensive prospection of local land races will certainly uncover new lines with genetic attributes that might prove useful to produce new varieties that will withstand the effects of climate changes.

6.4 Availability of labor and the poverty reduction imperative

The DRC population stands today at 102 million people [64] with 54% living in the rural areas. The unemployment rate is officially set at 4.99% for 2022 [65], but

this figure represents the share of the labor force that is without work but available for and seeking employment. In the rural areas where opportunities for employment are scarce, people engage in subsistence agriculture, in petty trading or are self-employed without being registered with an employment service and therefore are not counted as unemployed. The number of people in need of a regular income is very high. The minimum wage in DRC is set by law at 7,075 Congolese Francs (EUR 3) per worker per day [66]. In 2022, it was estimated at USD 92.47 per month [67], significantly lower than in Malaysia, where the minimum wage was raised from RM1,200 to RM1,500 (about USD 320) per month from 1 July 20231 [68], and lower than in Indonesia, where minimum wages range from USD 126 to USD 316 depending on the location [69].

6.5 Access to a large palm oil consumer base

The production of palm oil in DRC is primarily targeted at satisfying the local demand for this commodity. In 2022, palm oil consumption in DRC was estimated at 425,000 metric tons [70], while domestic production is currently estimated at 300,000 metric tons [71]. Palm oil is consumed daily by the over 100 million people of DRC. Local prices for the commodity vary widely between location, from CDF 3,000 to CDF 6,000 [72].

A strong demand for palm oil exists in all the countries around the DRC. In 2019, the demand for palm oil of African countries was 7.31 million metric tons. Against a local production of only 2.79 million tons [73]. This demand grew at over 6% per year for the period 2010–2019 and is expected to continue to grow at this rate in the coming years. As a member of three trading and customs unions in Africa (Economic Community of Central African States (ECCAS), East African Community (EAC), and Southern Africa Development Conference (SADC)) and having joined the treaty of the African Continental Free Trade Agreement on January first 2021 [74], DRC is uniquely positioned to export to all the countries of the continent estimated to contain over one billion consumers.

6.6 Lessons learned from Malaysia and Indonesia

The accelerated development of the palm oil industry in southeast Asia has led to many concerns being raised regarding environmental sustainability of the palm oil industry. It was been estimated that 17% of the new plantations in Malaysia and 63% of those in Indonesia came at the direct expense of biodiversity-rich tropical forests over the period 1990–2010 [75–78] and up to 30% of this expansion occurred on peat soils, leading to large CO_2 emissions [79–81]. On the other hand, in Indonesia and Malaysia, which together account for around 85% of global palm oil production, the palm oil industry is credited for lifting millions of people out of poverty by creating millions of well-paying jobs in rural areas where alternative employment opportunities are scarce and enabling tens of thousands of smallholder farmers to own their own land [82]. In its State of Sustainability Initiatives report, the International Institute for Sustainable Development has estimated that in Indonesia and Malaysia, the palm oil sector employs almost 5 million smallholders and workers and a further 6 million people indirectly, while being responsible for nearly 3 million downstream jobs in importing countries [83].

To become the next frontier for the palm oil industry, DRC will need to focus on generating the positive impact that the palm oil industry has produced in southeast

Asia while avoiding or minimizing the negative consequences, especially on climate change and biodiversity. The state of knowledge today makes both objectives achievable. Some of the actions that could be undertaken are briefly mentioned below:

6.6.1 Identify socio-economic impact targets for the palm oil industry

The socio-economic impact of palm oil is complex and varies depending on several factors, including the region, local communities, and the practices of palm oil producers. Key aspects include employment in locations where few opportunities exist; income generation opportunities for rural dwellers with very few alternatives enabling them to support their families and improve their living standards; rural development opportunities through improved infrastructure such as roads and access to markets, which can stimulate economic growth and development in these regions; increased government revenues through tax payments; increased export earnings when palm oil is exported; technology and knowledge transfer on palm oil production and agriculture in general which can benefit local farmers and communities by improving agricultural practices; facilitated market access for other agricultural products and commodities, boosting the income of smallholder farmers and diversifying local economies.

However, there are negative socio-economic challenges that need to be considered and monitored and whose impact needs to be minimized. These include land displacement, particularly of indigenous communities and smallholder farmers; social disputes and conflicts over land ownership leading to social tension and unrest that can arise in areas where palm oil plantations are expanded; poor working conditions including low wages, and inadequate labor rights that can lead to social inequality and exploitation; workers' health concerns due to the use of pesticides and other chemicals in palm oil cultivation, affecting both workers and nearby communities; community health and well-being such as air and water pollution that can have direct health and well-being implications for local communities.

The socio-economic impact of palm oil is multifaceted. While it can provide employment, income, and development opportunities, it is also associated with challenges related to land displacement, social conflicts, working conditions, and environmental impact. The overall impact depends on various factors, including the practices of palm oil producers, government regulations, and efforts to promote sustainable and responsible palm oil production. Efforts to mitigate the negative socio-economic consequences of palm oil production often involve promoting sustainable and responsible practices, ensuring land tenure rights, and supporting smallholder farmers and local communities in palm oil-producing regions.

DRC has a young and rapidly growing population that needs access to adequate infrastructure and income opportunities. The example of Indonesia and Malaysia shows that such opportunities can be provided by the palm oil industry. In DRC, *Plantation et Huileries du Congo*, which with 30,000 ha of planted oi palm and three palm oil mills, is the largest private sector employer in the country, and through the social services it offers to its workers and neighboring communities, is the largest private provider of health services. It builds schools, maintains roads within its area of operations and supports local communities with development programs, facilitates the acquisition and distribution of primary and fast-moving consumer goods in the remote rural locations where it operates. This company intends to generate biogas from its palm oil mill effluents and converts that biogas to electricity, some of which will be made available to local communities that are currently disconnected from the national electricity grid.

The social and economic benefits that can accrue from the palm oil industry need to be quantified and set as national goals against which the growth of the industry in DRC would be measured.

6.6.2 Address environmental impact issues

Key environmental concerns associated with palm oil include deforestation, because the oil palm is naturally suited for growth in the forest ecology. Large areas of rainforests and other natural ecosystems, particularly in Southeast Asia (Indonesia and Malaysia), have been cleared to make way for oil palm plantations. Deforestation can lead to the loss of biodiversity, disruption of ecosystems, and the release of stored carbon dioxide into the atmosphere. The clearing of large tracks of land for palm oil plantations destroys the habitats of many endangered and endemic species, potentially putting these species at risk of extinction. The conversion of diverse natural ecosystems into monoculture oil palm plantations leads to a loss of biodiversity as plantations typically support far fewer species than the original forests.

Other negative environmental impact sources include air pollution when land clearing involves burning, and water pollution caused by excessive use of mineral fertilizers and plant protection pesticides on oil palm plantations; the chemicals used for this purpose can contaminate local water sources and negatively affect aquatic ecosystems.

In the past 20 years, substantial efforts have been made to address these environmental concerns. It started with the establishment of the Roundtable on Sustainable Palm Oil (RSPO) in 2004 to promote sustainable and responsible palm oil production through adhesion to global standards and multistakeholder governance [57]. The stakeholders involved in this initiative are oil palm producers, palm oil processors or traders, consumer goods manufacturers, retailers, bankers, and investors, environmental or nature conservation NGOs and social or developmental NGOs.

Popkin et al. [84] have shown that increasingly, oil palm plantation and mill managers are adopting management practices that reduce the negative impact of the industry on biodiversity and environmental processes. Such practices include planting high-yielding varieties, optimizing the application of organic and mineral fertilizers and maintaining a very high harvest quality index in fresh fruit bunches sent to the palm oil mill. Others include reliance on biological control of pests, the use of biopesticides and leguminous cover crops [85]. Precision agriculture with its information technology-based tools is used to minimize the use of mineral fertilizers, predict the effectiveness of planned best practices, or identify new sites for expansion of oil palm cultivation [86, 87]. The author has visited several oil palm plantations and mills in Indonesia where these and other practices have been adopted and where the objective is not only for their operation to achieve their Net-Zero Emission target, but possibly to become Net Carbon Negative, thus creating a palm oil business that effectively contribute to the global effort of bringing climate change under control and keeping the temperature rise to below 1.5°C required to avoid a climate catastrophe [88].

6.6.3 Adopt enabling policies and enforce regulations

In its quest to become the next frontier of the palm oil industry, DRC will need to formulate and adopt policy and regulations that are required to give rise to a sustainable palm oil industry that addresses all environmental, social, and economic challenges. Some key strategies and initiatives to be considered include the following:

a. Certification programs: Support and promote certification programs, such as the Roundtable on Sustainable Palm Oil (RSPO) and adapt the standard to DRC conditions to enable the conformity of DRC smallholder planters to the standard. Key industry actors should be encouraged to join platforms of excellence such as the Palm Oil Innovation Group (https://poig.org/). These programs and associated groups establish and monitor standards for environmentally and socially responsible palm oil production with a focus on conservation, community development, and responsible practices.

b. No deforestation commitments: Ensure that palm oil producers in DRC adopt a no-deforestation commitment. This means that palm oil production should not lead to the clearing of primary forests or other high-conservation value areas. Companies operating in the palm oil business should commit to protecting and preserving these areas.

c. Responsible sourcing: Encourage companies throughout the palm oil supply chain, including manufacturers, retailers, and traders, to source palm oil from certified and sustainable sources. This can create market incentives for responsible palm oil production.

d. Support smallholder farmers: Both Indonesia and Malaysia have shown that special programs to support smallholder farmers who cultivate oil palm are important to develop and strengthen the palm oil industry. Smallholder farmers need support with training, technical assistance, and access to resources so that they can in turn adopt more sustainable farming practices.

e. Alternative livelihoods: Not everyone in the rural areas will need to be involved in oil palm. Project for alternative livelihoods for communities should be develop to reduce dependence on palm oil production and help alleviate social and environmental pressures.

f. Conservation and restoration: Mitigate the environmental impact of palm oil production by investing in the conservation and restoration of degraded lands and ecosystems to offset deforestation and habitat destruction.

g. Transparent supply chains: Promote transparency in the palm oil supply chain. Recommend that companies in the palm oil industry disclose their sourcing practices and report on progress toward sustainability goals.

h. Research and innovation: Invest in research and innovation to develop more efficient and environmentally friendly palm oil cultivation methods, such as high-yield, low-impact planting techniques.

i. Government regulations: Governments in palm oil-producing countries should enforce and strengthen regulations related to land use, environmental protection, labor rights, and land tenure to promote responsible palm oil production.

j. Community engagement: Involve local communities in decision-making processes and ensure they benefit from palm oil production. Respect land tenure

rights and conduct social impact assessments to assess and mitigate potential negative consequences.

k. Environmental and social impact assessment: Prior to establishing new plantations, conduct thorough assessments of the potential environmental and social impacts of palm oil projects. These assessments should inform project planning and design.

l. Traceability and accountability: Implement systems to trace palm oil throughout the supply chain to ensure that it comes from responsible sources. Hold companies accountable for their sustainability commitments.

Achieving a truly sustainable palm oil industry requires a multi-stakeholder approach involving governments, businesses, non-governmental organizations, local communities, and consumers. The goal should be to balance the economic benefits of palm oil production with environmental and social considerations, ultimately leading to a more responsible and sustainable industry. Efforts to promote sustainability are ongoing, and progress has been made. As it embarks on expanding its palm oil production capability, DRC should formulate policies, regulations and incentives to ensure that the industry will follow a sustainable course and avoid mistakes that were made elsewhere.

6.6.4 Facilitate financing processes

Financial analysis of investment in palm oil shows that it is a very profitable undertaking [89], even though it takes three to four years before income could be generated from a new oil palm plantation. Financial resources required to gainfully participate in the palm oil industry are substantial and often beyond the means of smallholder farmers and low income citizens. Development finance that used to be available from Development Finance Institutions such as the World Bank and the International Finance Corporation stopped in 2009 because of pressure from non-Governmental Organizations but seems to be ready to resume [90].

Public finance for agricultural projects has not been successful in Africa, and in particular in DRC [91, 92]. Innovative approaches are needed that will target progressive private sector companies with clear and verifiable environmental, social and governance (ESG) policies.

7. Conclusion

Countries of the equatorial belt where oil palm can be commercially grown need to use this highly efficient natural source of vegetable oil in the pursuit of their social and economic advancement. At the same time, they have become aware of and are committed to the protection of their natural resources and environment to secure a sustainable future for their generations yet unborn. These two seemingly competing demands can be reconciled, but it will take strong collaboration between producers and users of palm oil to limit, and even reverse, the contribution of the palm oil industry to climate change.

This chapter has shown that the DRC has played a key role in the birth and development of the palm oil industry and that only six decades ago the country was the

second largest exporter of palm oil in the world. It has lost that position today and is not even counted among the ten largest palm oil producing countries. Nevertheless, the country's assets needed to become a large producer of palm oil remain intact. Land, labor, and high-performance oil palm genetic resources are available in large quantity. The weather in DRC is conducive to oil palm cultivation, and even though climate change will most likely reduce the suitability for oil palm production in Africa, science-based projections suggest that the largest are of suitability for oil palm cultivation up to the year 2100 will be in the DRC.

The development of the palm oil industry in the Congo Basin, the largest carbon sink in the world and where historically the palm oil industry began, could be realized in a way that contribute to pathways which limit global warming to 1.5°C as recommended by the Intergovernmental Panel on Climate Change (IPCC) to avoid a climate catastrophe [88]. Innovations that reduce carbon emissions are already in application in oil palm plantation in several countries, while others are in the pipeline. *Plantations et Huileries du Congo*, the largest industrial producer of palm oil in the DRC, has demonstrated that in a very short period of time (less than three years), adoption of science-based, data-driven, environmentally and socially conscious management practices could lead to significant productivity increase enabling the company to meet the triple bottom line of improved welfare for its workers and surrounding communities, sustainability for the planet and acceptable return on investment. This example is offered as a proof of concept upon which a larger program can be built to take DRC back among the key palm oil producing countries.

Conflict of interest

The author is an employee of *Plantations et Huileries du Congo* mentioned in this chapter. However, the statements and ideas expressed in this chapter are solely his own and do not necessarily reflect the position of the company or of its owners. No compensation or favor of any kind has been received for the writing of this chapter.

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