Chapter

Environmental Impacts of the Oil Palm Cultivation in Cameroon

Tchindjang Mesmin, Ludovic Miaro III ,
Fideline Mboringong, Gilles Etoga, Eric Voundi
and Emmanuel Pierre Jonathan Ngom

Abstract

Since 1990, oil palm cultivation, because nibbling large zones in dense forest areas of Cameroon, becomes the main driver of deforestation. It leads to the loss of plant and animal biodiversity as well as engaging soils and water pollution, which raises questions about its sustainability. Nowadays, palm plantations occupy almost 400 000 ha shared between agro-industries, elites and small farmers while annual palm oil production increased from 150, 000 tons in 2000 to 413,000 tons in 2018 against a demand that peaked at 1.179 million tons in 2018. This would assess the impacts of the oil palm exploitation in Cameroon. The objective of this article is to analyze the four dimensions of impacts closely linked to sustainability dimensions (ecological, sociocultural, economical and institutional) dimensions of sustainability of the oil palm sector in Cameroon. The approach is based on field surveys carried out in various production basins, particularly in the South-West, Littoral and Central regions. They also take into account the resolutions of various workshops bringing together stakeholders on the matter of sustainability in the oil palm sector in Cameroon. Satellite images were also used to map the spatial evolution of oil palm in the production basins. The result is a boom and a considerable expansion of the oil palm to which we can note a lack of adequate policy due to the constraints and hesitations of the Cameroonian administrations. Such a situation requires a better articulation of the tensions between development and environmental issues in Cameroon.

Keywords: Cameroon, deforestation, environmental impacts, oil palm, sustainability

1. Introduction

In recent years, many developing countries worldwide have been tapping renewable resources for food security. Such a tendency has been spurred by high demand in some commodities and also and increasing concerns in agriculture feedstock. Agriculture is one of the main causes of the degradation of natural ecosystems [1, 2]. It accounts for 24% of global greenhouse gas emissions [3]. The resulting climate changes affect the whole humanity [4]. Agriculture is also the primary anthropogenic cause of deforestation and desertification. It greatly participates in the degradation of water resources with the increased use of chemical inputs [5].

These negative impacts are mainly attributable to industrial agriculture, practised over large areas and without taking into account the basic principles of sustainability. Artisanal agriculture also presents unsustainable practices such as shifting slash-and-burn agriculture [1, 6]. Among the most incriminated is oil palm cultivation [2, 7]. This plant, which is native to the Gulf of Guinea, has experienced strong expansion around the World [8, 9]. It is planted for its oil, which is currently the first vegetable oil seconded by soybean oil [10]. Southeast Asia (Malaysia and Indonesia) accounts for 80% of world production of palm oil [11]. Effort to render palm oil production sustainable (Round Table on Sustainable Palm Oil and Belgian Alliance for Sustainable Palm Oil) has led to 19% of its worldwide production certified as organic [12]. In recent years, Africa has consolidated its position as the Third production pole. There is increasing rush for its production by national and international investors, attracted by the availability of land [13]. Such a rush raises concerns captured by this paper such as reconciling increasing production of palm oil and preserving the forest and biodiversity for the sustainability of the oil palm sector in Cameroon.

WWF report estimates that palm oil supplies 35% of the world's vegetable oil on just 10% of the land. In Cameroon, oil palm exploitation is taking a global scale. Since economic crisis of the year 1990s, Cocoa and coffee have already lost ground while the rubber tree is floundering. The palm oil is reassuring, because of its many uses.

People are getting more involved in the activity because of its economic importance (money like cash crop at any time, cultural uses and benefit, etc.). Estimations on oil palm plantations reach 375 000 ha shared between agro-industries, elites and small farmers. Annual palm oil production increased from 270,000 tons in 2013 to 413,000 tons in 2018 against a demand that peaked at 1.179 million tons in 2018 [14]. Oil palm expansion in Cameroon has been driven by rising global demand for vegetable oils for consumption and cosmetics. While making a significant contribution to national economies, the expansion of oil palm plantations is a cause for environmental concerns.

Most plantations, as well as CPO productive basins, are located in the rainiest area of the country, being South West, Littoral and some part of the Centre and South regions. Between 2000 and 2020, more than 10,000 ha of oil palm plantations were established annually. Gradually, new lands available were allocated for industrial plantations while concerns on deforestation were raised up.

This paper assesses and analyzes the environmental impacts and risks associated with this activity. The main assumption is that oil palm cultivation generates ecological and socio economic impacts which put its sustainability to question. The approach is based on field surveys carried out in various production basins, particularly in the South-West, Littoral and Centre Regions. The study reviewed resolutions of various workshops bringing together stakeholders on the matter of sustainability in the oil palm sector in Cameroon. It emerges that impacts are assessed in four domains: ecological, economic, social and institutional. The latter implies a better articulation of the tensions between development and environmental issues.

2. Methods

2.1 Research sites

Within the oil palm production basins of Cameroon, three main sites were chosen to drive this study namely Sanaga Maritime Division in 2013–2014, Ngwéi (2016–2018) and Ekondo-Titi (2016) Subdivisions (**Figure 1**). The diversity of the biophysical environment favours the cultivation of a wide variety of food (cassava, maize, millet, macabo, rice, etc.), and cash (sugar cane, cotton, palm oil, rubber,

cocoa, etc.) crops (Tchindjang et al. 2015–2016). Regarding oil palm, it develops preferentially in the coastal area qualified as the "elaeisfarming" belt of Cameroon (**Figure 1**). Administratively, oil palm plantations and concessions are set up in the maritime facades of the southern, coastal and southwestern regions [10, 15, 16].

As shown by Tchindjang et al. [17] and Ndjogui [18], oil palm belt offers suitable conditions for the development of oil palm: low altitude (less than 500 m); sufficient rainfall (more than 1800 mm/year); favorable temperature between 22 and 30°C; low thermal amplitude; rich and deep soils; etc. Agro-industries are also common in this area and constitute the major producers of palm oil (**Table 1**). At the edge of this "elaeisfarming" belt, there are a few small marginal farms both on the vast southern Cameroonian plateau and in the Western Highlands where oil palm could be grown with limited success.

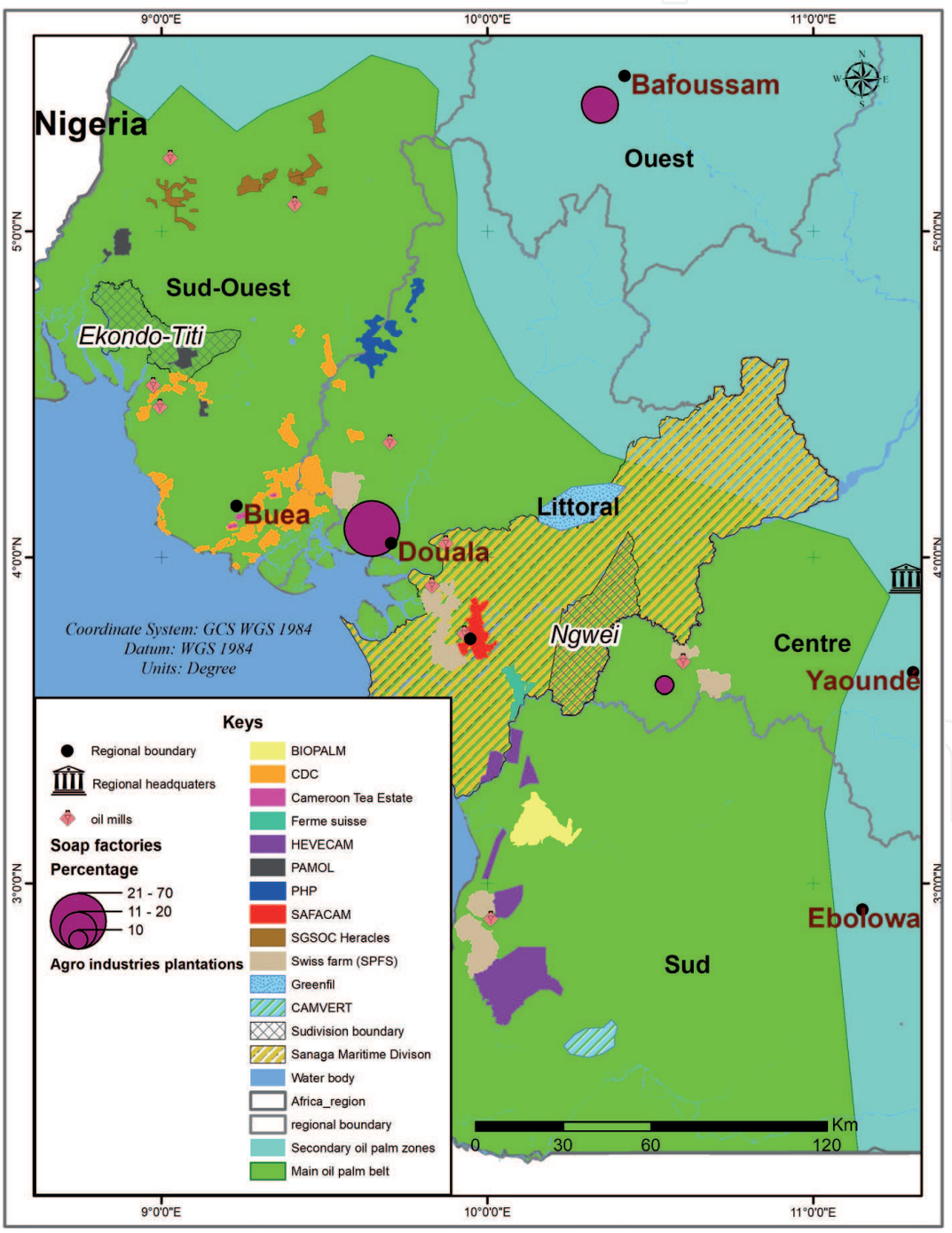

Figure 1.
"Elaeiscultivation" areas, oil pam farms and industries of Cameroon.

Parameters	Sanaga Maritime	Ngwéi	Ekondo-Titi
Area in sq. km	9311	848	652
Number of Protected areas	3 (179,661 ha)	0	0
Number of agro industries	3	1	2
Name of agro industries	SAFACAM, SPFS, SOCAPALM	SOCAPALM	PAMOL and CDC
Planted areas (ha)	30,000	5,000	25,000
Labor regime	Workers and farmers	Workers and farmers	Workers and farmers
Number of Elite oil palm owners	5	1	2
Number of Small holders	3000	398	550
Type of Soils	Oxisoils, yellow ferralitic soils	Oxisoils, yellow ferralitic soils	Volcanic soils and peat lands
Land cover	Primary and secondary forest	Primary and secondary forest	Primary, secondary forests and mangroves
Number of Landsat satellite images processed	9 Landsat, 5 Spot, 3 Ikonos, 1 Geoeye	3 Landsat, 1 Google Earth 1 map box 1 Geoye	3 Landsat, 1 Google Earth, 1 map Box

Table 1.
Summary of the research sites.

2.2 Methodological approaches

This work constitutes an analytical and conclusive synthesis of the research carried out, participative field investigations and works undertaken in production basins since 2013 (from 2013 to 2018) under the framework of the palm and forest project of Cameroon (PALMFORCAM-IRD) as well as Oil palm Adaptative Landscape (OPAL). The main missions included:

- Investigations carried out within the framework of the PALMFORCAM project funded by IRD, took place in 2013–2014 [5]. The objective was to monitor by remote sensing the impact of the development of village oil palm plantations on the forest cover in the Sanaga Maritime Division. The methodological activities set up concerned: (1) Carrying out an inventory of the palm plantations in the Sanaga Maritime with collection of GPS waypoints, without forgetting to identify the types of owners and the sizes of the plantations; (2) Diachronic mapping (Landsat, SPOT, IKONOS and GEOEYE images) of land use in the Sanaga Maritime Division in 1975, 2000 and 2013.

- The OPAL project drive us to study the environmental impact of village/elitist palm plantations on deforestation in Sanaga Maritime and in the Ndian basin: the case of Ngwéi and Ekondo-Titi subdivisions. This study, carried out between October 2016 and March 2017 by an interdisciplinary team (geographers, botanists, environmentalists and geomatician specialists), highlighted the impact of oil palm cultivation on the landscape and the range of tools used during this study are resumed in **Table 2**.

The quadrate method is advantageous because it helps in studying the dynamics of the fauna and flora in a quantitative and qualitative approaches. As flora recording is concerned for the analysis of the impact of oil palm farming on

Methods	Operational work
Satellite image processing	LANDSAT image processing (MSS, TM, ETM+ & 8 de 1975 to 2015), MAP Box images (1.5 m resolution)
Botanical Survey on quatrates and transects	Two quadrates and two transects in each palm plantation visited on the field (village, elitist et industrial); a quadrates in the dense forest.
Environmental impacts assessment	Interaction matrix and impact sheet per receiving environment
Questionnaire Survey	330 questionnaires in Sanaga Maritime (2013) 290 and 260 copies of questionnaires administered in Ngwéi and Ekondo-Titi Sub-divisions respectively (2016)
Landscape methods	Application of the SEPL exercises in these areas.

Table 2.
Methods used in assessing the impact of oil palm plantation in the environment.

plant biodiversity, experimental plots were applied on four types of vegetation's namely: a village or smallholders oil palm plantations, an elitist oil palm plantations, an industrial palm plantation and a forest area. To this effect, the team realised an experimental plot where recorded plant species were immediately identified.

Criteria such as the nature, probability of occurrence, scope or extent, magnitude or intensity, reversibility and duration of the identified impacts were combined for an appropriate impact assessment. The rating grid of Leduc and Raymond [19] was used for impact assessment. Ratings from 1 to 5 were assigned to the indicators (**Table 3**) depending on the degree of impact. The absolute importance represents the average of the impact ratings over the total number of rated indicators. The nature of an impact can be positive (+) ▲ or negative (−) ▼ on the environment concerned.

The absolute importance or significance of the impacts is determined by calculation by taking the product of all the ratings assigned to each indicator over the total number of indicators. This is illustrated by the following equation:

Value	Occurrence of the impacts	Territorial scope (extent) of the impacts	Duration of the impacts	Intensity of the impacts	Reversibility of the impacts	Final rafting
1	Very unlikely	Very reduced space (10%)	Very short	Very weak	Immediately reversible	1–2 non significant or negligible
2	Unlikely	Reduced space 15–20%	Temporary	Low	Quickly reversible	
3	Likely	Fairly extensive 25–40%	Long enough	intermediary	Reversible	2.1–2.9 insignificant
4	Certain	Extended 50%	Long	High	Little reversible	3–4 significant
5	Very certain	Very extensive 60–100%	Very long	Very high	Irreversible	4.1–5 very significant

Table 3.
Impact assessment indicators and rating of their impacts.

$$\text{Absolute importance} = \frac{\sum Ratings\left(\text{intensity x reversibility x extent x duration xoccurence}\right)}{5} \quad (1)$$

After rating the impacts were qualified according to the results obtained.

- The rating between [1–2] represents the insignificant or negligible impacts;
- The rating between [2.1–2.9] represents the insignificant impacts;
- The rating between [3–4] represents the significant impacts;
- The rating between [4.1–5] represents very significant impacts.

The critical impact threshold is established when the rating value is greater than or equal to the average of the grid: 3.

To complete methodology and tools used, it is worth mentioning that oil palm is one of the most studied agricultural speculations in Cameroon today. Its cultivation and oil production are of interest to economists, sociologists and anthropologists because of its income-generating character and the by-products are used in traditional pharmacopoeia. With further investigations carried out in the Sanaga-Maritime oil production basin (2018–2020), under the coordination of WWF and EPFL Switzerland, three work packages have been developed since 2018 till 2020 on the intercropping of oil palm:

- Analysis of the conversion of forests into "elaeisfarming" agrosystems, dynamics of the oil palm in this new environment.
- Analysis of the impacts of palm plantation management on soil fertility.
- Socio-economic impacts of the management of palm plantation in the main "elaeisfarming" production basins of Cameroon.

This study also take into account various meetings held with the actors of the Africa Palm Oil Initiative (APOI), whose objective is to seek and support the transition to a sustainable palm oil not linked to deforestation in Central and West Africa.

3. Results and discussion: environmental impacts of the oil palm in Cameroon

Paragraphs below allow to address the main impacts identified into the oil palm sector being ecological, economic, social or institutional. Fieldwork observations show that most of the components of the biophysical environment are affected by this activity. Globally, it is noticed the clearing of the forest for the establishment of new plots, the erosion of the land during exploitation, the pollution of air and water during processing as well as relative poverty and inequality among peasants. One can include grievances related to the distribution of benefits and the development of neighboring.

3.1 Ecological impacts of oil palm

There are so many ecological impacts of oil palm identified namely deforestation, loss of biodiversity, erosion as well as soils and water pollution or contamination.

3.1.1 Oil palm cultivation and deforestation

Ecology of the oil palm shows that the forest area has the suitable conditions (soil, rainfall, temperature, relief and insolation) for its development. It is in this vein that all old and new palm plantations (from all actors being agro industries, small farmers and elites) are located in forest areas. This is because forest milieu guarantees them a sustained production over a long period while others areas like fallows and abandoned farms do not bring the expected results (**Figure 2**).

It is worth notice that agro industrial palm plantations/concessions and properties are 100% created on forests. The areas of industrial oil palm producers increased from 46,850 ha in 2009 to 63,200 ha in 2014 and more than 176,600 ha in 2019. It means 35% increase in about 5 years and 73% in 10 years. Similarly, remote sensed data in Ngwéi and Ekondo-Titi Sub-divisions show that more than 83% of smallholders palm plantations were created in both primary and secondary forests. Increase in smallholders palm plantations is estimated at more than 50% in 10 years between 2000 and 2010. The latter do no longer used fallow land and other abandoned fields. Because there are so many smallholders actors more than 90% for only 15% of area, the accelerated deforestation process by atomizing the forest. Atomization of the forest by unsustainable oil palm worsen practices (construction or building, clearing, palm plantations and wasteland) contributes enormously to the decline of the forest which is suffocated. Any parcel of forest located between two or more of these plots is doomed to disappearance.

The threat of palm plantations on the original forest is all the more serious as certain industrial concessions granted in recent years are adjacent to protected areas. This is the case of Sithe Global Sustainable Oils Cameroon (SGSOC); a subsidiary of the American multinational Herakles Farms. The concession acquired by the latter is located near protected areas (Korup and Mounts Barossa national parks, Rumpi hill reserve and Banyang-Mbo fauna sanctuary) recognized as High conservation value forests (HCV) and also endemic for its biodiversity. The same situation was observed in the Greenfil case whose palm plantations are located very

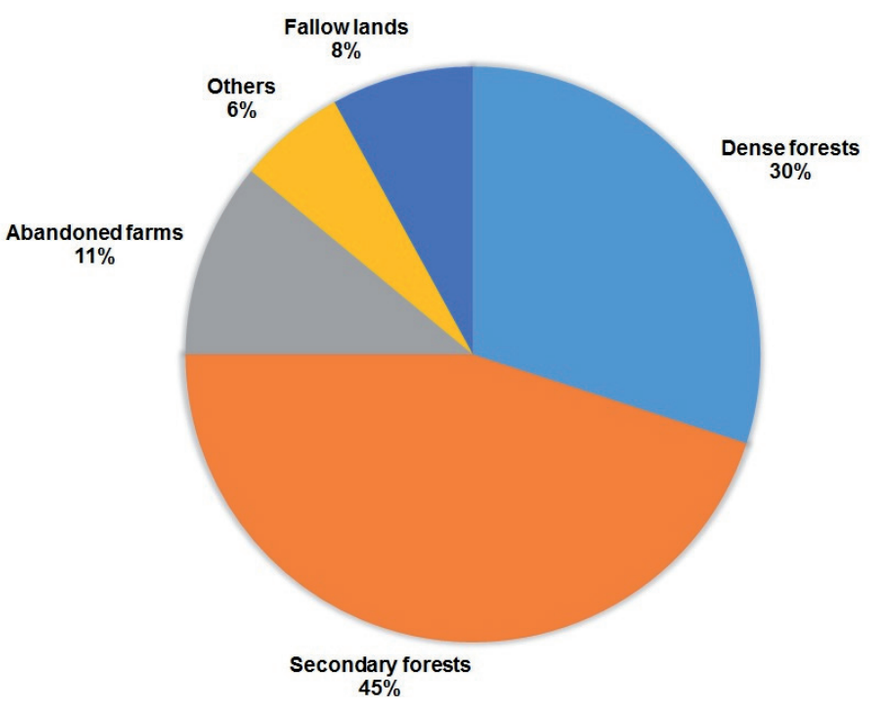

Figure 2.
Type of land use chosen for the creation of oil palm plantations in the main production basins (Source: field survey 2013–2020).

close to the Ebo forest which plays host to a wide variety of wild animals, especially the western gorilla, the Nigeria-Cameroon cross boarder chimpanzees, drills and several other primates as well as many endemic plant species. Another case is the 2019 de-gazettement of Forest Management Unit (FMU) number 09–025 near the famous Campo Ma'an National park for its transformation into oil palm (60,000 ha) plantation by CAMVERT. This National Park is recognized as Model forest and Biosphere Reserve. The proposed declassified area encompasses two blocks covering 40,000 ha to the north and 20,000 ha to the south bordering Dipikar Island (Campo Ma'an National Park) where there is a gorilla habituation project ongoing.

Deforestation caused through palm planting also fragments the habitat of endangered species and disturbs wildlife corridors usually used by forest elephants. Such a situation bring confusion and more and more anger, disappointment and land conflicts due to ambiguous governance of the forest. This issue is discussed in the following paragraph.

As the ecological impacts are concerns, there is a high degree of confidence that the expansion of palm oil cultivation has resulted in deforestation. Numerous authors and reports have emphasizes on oil palm as a driver of deforestation and land-use change in tropical countries [20]. Globally, oil palm crop development is responsible for less than 0.5% of deforestation, but in parts of the tropics this figure can reach 50% [21]. For Indonesia, the proportion of direct and indirect deforestation linked to the expansion of elaeis farming is estimated to be between 11% (2000 to 2010) and 16% (1990 to 2005). At the same time, in 2016, in the same country, 45% of oil palm plantations were on land which, in 1989, was forests [22, 23]. This phenomenon is very marked in Malaysia and Indonesia because they are the two largest palm oil producers in the world. With an average forest loss of 350,000 hectares annually, deforestation is particularly dramatic on the island of Borneo, where about half of the deforestation between 2005 and 2015 was directly linked to industrial oil palm plantations [21, 24]. As shown by [25], 2/3 of deforestation in the South-West region of Cameroon during the same period was caused by the expansion of oil palm farms and the installation of new actors. The peculiarity of oil palm basins areas compared to the rest of Cameroon is that they host most of the agro-industrial activities (oil palm, rubber, plantain and sugar cane). To this should be added the share of deforestation generated by small producers, which is still unclear. In addition, oil palm plantations are responsible for significant greenhouse gas emissions.

3.1.2 Elaeiscultivation and the loss of biodiversity

The establishment of palm plantations generally involves the almost total clearing of the forest. This leads to the loss of species, including those that are endogenous in certain areas of high conservation value. Oil palm is generally grown in pure culture. It doesn't tolerate association with other commodities. The other species found in palm plantations are generally the ombrophilous grasses. **Table 4** built with quadrates and transects methods, shows the numbers of species, families, and individuals recorded in the oil palm cultivation basins of Ngwéi and Ekondo-Titi compare to those of protected areas bordering these basins. One can observed that less than half of the species present in humid forests are present in industrial plantations. It is the same for the number of families which decreases between the mangroves and different forms of palm plantations. From the table below, smallholders palm plantations conserve their biodiversity better than industrial one. This is explained by the solicitation of other ecosystem services such as traditional pharmacopoeia and the harvesting of non-timber forest products by populations.

From the **Table 4** above, out of the 18 families in moist and dense forest and 20 families in the mangrove, only 5 families are found in all palm plantations (village,

Type of area	Number of species	Number of families	Number of individuals
Ekondo-Titi – 2016			
Dense and humid forest	48	18	162
Mangrove	37	20	178
Smallholders' plantations	45	24	76
Elites plantations	38	25	159
Industrial plantation	21	15	78
Ngwéi – 2016			
Dense and humid forest	50	26	142
Smallholders' plantations	31	19	39
Elites plantations	60	32	88
Kribi, Campo, Douala areas – 2020			
Campo Ma'an National Park	108	36	98
Kribi Marine Park	72	26	65
FMU 09–025	69	27	60
Douala Edéa National Park	59	31	54

Fieldworks quadrates and transects Survey 2016 & 2020.

Table 4.
Floristic diversity between palm plantation and forest of Ngwéi and Ekondo Titi subdivisions and some protected areas around Kribi and campo.

elitist and industrial). These include *Annonaceae, Apocynaceae, Euphorbiaceae, Fabaceae* and *Loganiaceae* as well as *Moraceae* found in wet and dense forests and in the elitist and villager oil palm plantations and *Phyllanthaceae* found in the mangroves and in the elitist and smallholders plantations. This constitutes either a real quantitative and qualitative decrease in biodiversity outside the *Fabaceae* families. The number of families, however, increased in the elitist (25) and smallholders (24) oil palm plantations of Ekondo-Titi. In protected areas and FMU, families range from 26 to 36 meaning that oil palm is a driver of deforestation. Therefore, the least diversified plots are the smallholders' farms, followed by industrial and finally elitist palm plantations. This can be explained by the regular maintenance of industrial palm plantations, the mixed food crops grown in some village palm plantations and the irregularity of the maintenance in the elitist oil palm plantations.

Conclusively, the clearing of hundreds or thousands of hectares of land for oil palm cultivation is one of the most important factors in the destruction of vegetation cover and consequently of biological diversity. Deforestation and degradation are the root cause of a considerable loss of flora species, fragmentation and disturbance of the natural habitat in these areas. The original evergreen natural forest has disappeared in favour of the mono-specific oil palm plantations, which occupy three-tenth of the territory, but catalyse deforestation. Also, aggressions on forests and fallow lands for oil palm establishment create enormous pressure on traditional and modern land reserves and protected areas.

3.1.3 Floristic diversity index

The measurements from quadrates and transects allow to calculated many indices. The Simpson index which measures rare species is roughly equal across

the four project sites. The equitability of Pielou, which provides information on the distribution of species, is approximately equal in the different sites sampled. The Shannon index, which takes into account floristic diversity, is higher in PNCM (4.01) and similar in PMK, PNDE and UFA. (**Table 5**). The Shannon index (**Table 5**) shows significant biological diversity for dense forests and for mangroves (0.28). The Shannon index is also high for the industrial palm plantation of Ekondo-Titi, relatively less for the village palm and elitist palm plantations. The Simpson index is 0.08–0.09 in mangrove, moist and dense forest compared with 0.07 in the industrial and elitist palm plantations of Ekondo-Titi against 0.01 in the smallholders and elitist palm plantations of Ngwéi. Simpson index shows the degree of land use in the two districts. This is due to the fact that ecosystems are profoundly affected by agricultural practices and especially by oil palm cultivation (and even cocoa farming with exotic species), which reduces density and specific diversity locally.

3.1.4 Dynamics of plant biological and fauna diversities

Before concluding this section, it would be important to highlight the variation in floristic and wildlife biodiversity from natural environments to oil palm plantations. This would give and idea of the real impact of oil palm plantations on the biodiversity decrease within the landscapes studied. Taking the floristic level, **Tables 4** and **5** show that biodiversity in terms of species and families is so important in protected areas and dense forest than anywhere else. This is quite conspicuous in Campo Ma'an National Park. Hence the advantage of avoiding installing oil palm plantations next to protected areas or in dense forests because they considerably reduce biodiversity.

As fauna is concerned, the survey show that forest degradation is one of the major infringements to the loss and decline of wildlife for more than 50% of the surveyed population. It happens through the clearing of hectares of forest land which drive to

Types of land use	Shannon index	Equitability of Pielou	Simpson index
Ekondo-Titi			
Wet and dense forest	0.27	0.01	0.08
Mangrove	0.28	0.01	0.09
Smallholders palm plantations	0.20	0.00	0.02
Agro industries palm plantations	0.27	0.01	0.07
Elitist palm plantations	0.25	0.01	0.06
Ngwéi (Makondo)			
Wet and dense forest	0.28	0.01	0.09
Smallholders oil palm plantations	0.21	0.01	0.01
Elitist oil palm plantations	0.18	0.00	0.01
Protected areas			
Kribi Marien Park	3.56	0.83	0.95
Campo Ma'an National Park	4	0.85	0.96
Douala-Edéa National Park	3.56	0.87	0.96
FMU 09–025	3.57	0.84	0.95

Table 5.
Biological diversity index.

the destruction of wildlife habitats and the disappearance of species. There are almost any game (porcupines, monkeys, antelopes, etc.) and some species have already completely disappeared from the area (such as the elephant that disappeared from Njock-Loumbe, *Njock* meaning the elephant). In addition, the oil plantation guards confiscate the small mammals such as rodents that are caught in these single-crop farming.

Biodiversity impacts is the most documented facet of environmental oil palm effects. Land clearance for oil plantations removes, fragments and damages important wildlife habitats, leading to a high loss of species. The species these forests support are highly adapted to rainforest habitats and are often unique. Clearing tropical forests for oil palm results in strong local and regional biodiversity declines [21]. It is link to the fact that oil palm is commonly produced in monocultures which affect the habitat of great mammals and their biodiversity declines from 47 to 90% [26] or 65–90% [23]. Also, the mammal diversity in oil palm strongly depends on the proximity of natural forests [21, 26]. In Cameroon, great APES are endangered by the spread of oil palm plantations around protected areas like Campo Ma'an, Ebo, Korup etc. And in other areas, due to oil palm expansion, elephant have disappear like in Njockloumbe village at Ngwéi. The IUCN Red List of Threatened Species documents 321 species for which oil palm is a reported threat [21]. Meijaard et al. [26] added that species those threatened are made up 3.5% of the taxa threatened by annual and perennial non-timber crops (9,088 species) and 1.2% of all globally threatened taxa (27,159 species) in 2019.

As we saw on **Table 4**, the highest diversity of animal species in oil palm areas, however, is generally found in the wider landscape that includes remnant patches of native vegetation. Factors that are likely to positively influence biodiversity values in both industrial-scale and smallholder plantations include higher landscape heterogeneity, the presence of large forest patches and connectivity among these and the plant diversity and structure of undergrowth vegetation.

It is clear that oil palm becomes the source of deforestation and land degradation. The statistics compute from image processing help calculating the deforestation rate in the main studying sites. In Sanaga Maritime, from 1986 to 2013, deforestation rate is estimated at 23.61%. Ngwéi deforestation is estimated at 45.94% in 38 or 40 years, with an overall rate of 697.22 ha/year between 1975 and 2013. Deforestation in Ekondo-Titi is accessed at a rate of 22.74% in 37 years, i.e. 0.61% per year and especially 150.34 ha/year of Atlantic forests against 67.07 ha/year for mangroves. Let's take the detail case of both Ekondo-Titi and Ngwéi subdivisions to illustrate the results of images processing (**Figures 3** and **4**).

Table 6 emphasizes the synthesis of deforestation linked to the expansion of oil palm. The estimate of total deforestation varies according to administrative units and the dynamics of elaeis cultivation, and in this sense, the Ngwéi landscape appears to be more threatened.

Table 7 summarizes the perception of the populations in terms of ecological impacts. This shows the illusion that the people of Sanaga Maritime and Ngwéi have of thinking that the situation is not changing and of underestimating the deforestation linked to palm oil. However, they have clearly seen the decrease in wildlife. On the other hand, Ekondo-Titi recognizes the impact of oil palm cultivation both on the forest and wildlife.

Table 8 below shows negligible positive impact (3.5%) on fauna and NTFPs with overwhelming negative impact (55) (96.5%), meaning that oil palm cultivation largely undermines the resilience of the natural environment. The impact is more on surface water, flora and fauna (biodiversity), soils, natural habitats and non-timber forest products (NTFPs).

Based on remote sensing techniques, one can deduce that in the various literature, the case of Indonesia and Malaysia have been well identified compared to African

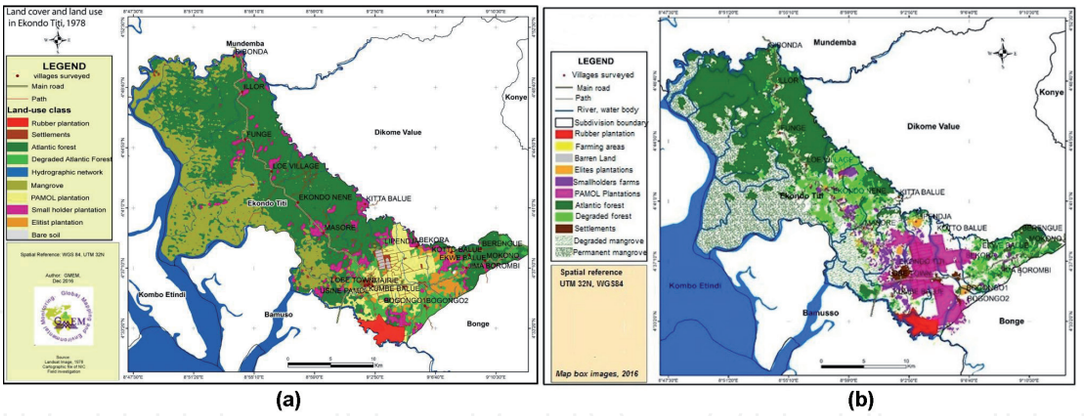

Figure 3.
Land cover and land use in Ekondo-Titi between 1978 and 2016 thanks to Landsat (1978), Map Box images (1.5 m resolution) and Google Earth (2016). The original forest and mangrove has disappeared everywhere apart from the North western part of the map. Smallholders' farms are spreading north western wards.

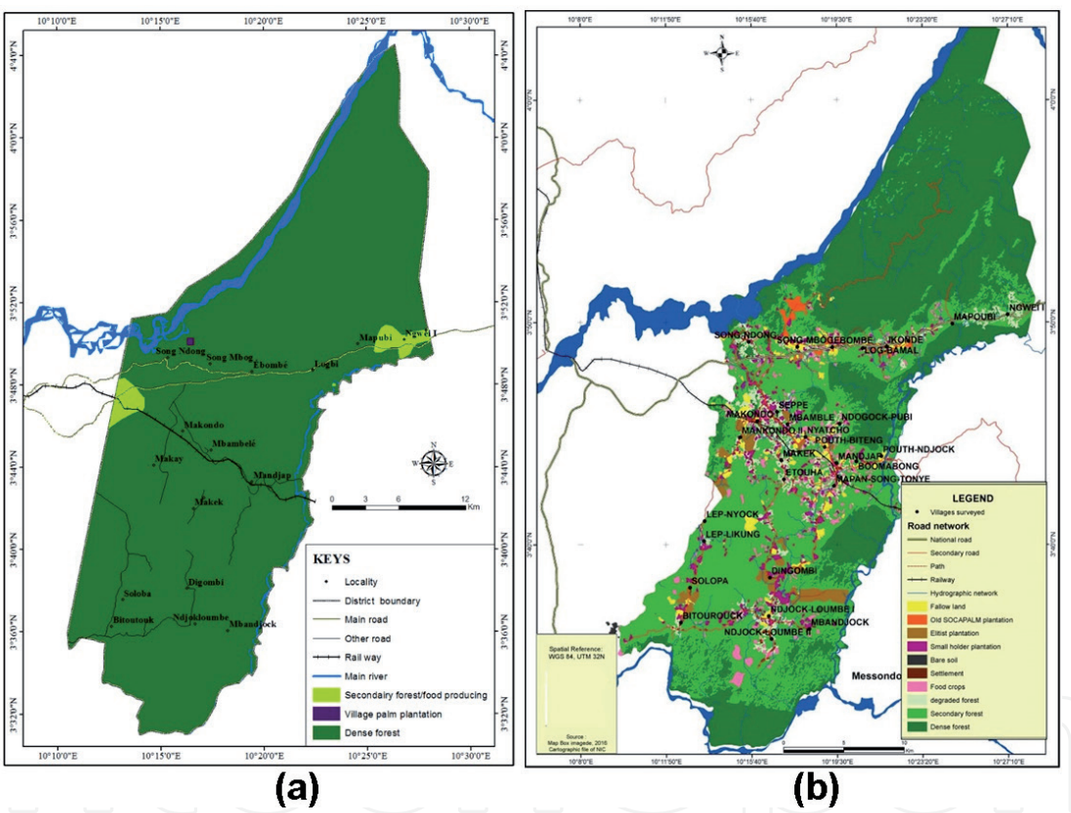

Figure 4.
Land cover and land use in Ngwéi District between 1975 and 2016 from Landsat (1975) and Google Earth image. A small portion southwards and a great areas northwards of the images remains intact and need to be preserved. Numerous smallholders' farms oil palm widespread and scattered in the central part of the image show that the Ngwéi District is the hold almost more than 30% of the areas producing red oil within the Sanaga Maritime Division.

countries producers like Nigeria, Ghana, Ivory Coast and Cameroon. Remote sensing studies of a subset of plantations in 20 countries suggests that around 45% of oil palm plantations in Southeast Asia came from areas that were forests in 1989. The estimates vary from one region to another being at 31% in South America, 7% in Africa and 2% in Central America. For Indonesia and Malaysia, the estimates were 54% and 40% respectively [22, 26, 27]. Another estimation gave during the last 40 years, 47% and 16% of total deforestation by oil palm in Malaysia and Indonesia, respectively [21, 28]. Those statistics could be compared to what we observed in Ngwéi (45,94%)

Parameters	Sanaga Maritime	Ngwéi	Ekondo-Titi
Area in sq. km	9311	848	652
Total deforestation rate	28% in 40 years	45,94% in 40 years	22,74% in 37 years
Mean annual rate	0,7% per year	1.15% per year	0,61% per year
Net deforestation (ha)	121,043 ha	11,872	7,882
Deforestation due to oil palm (ha)	65,177	7,632	3,977
Time span projected for the disappearance of the forest	50–70 years	37–50 years	125–189 years
% Oil palm expansion occurring at the expense of the forest	70%	90%	60%

Table 6.
Deforestation and oil palm expansion in the three sites.

Area	Sanaga Maritime (n = 335)			Ngwéi (n = 290)			Ekondo-Titi (n = 260)		
Impact	**N**	**No change**	**P**	**N**	**No change**	**P**	**N**	**No change**	**P**
Threat on forest	44.5	33.4	22.1	33.2	43.2	23.6	20.39	28.85	50.77
Economic	15	7	78	5	5	90	7	3	90
Animal BD	65.51	23.24	11.25	47.52	33,28	19.2	58.53	25	16.47

Table 7.
Perception of livelihood ecological impacts through questionnaire and landscape methods.

and Ekondo Titi (22,74%) as well as Sanaga maritime (23,61%) productive basins. According to Ordway et al. [25], oil palm expansion dynamics in sub-Saharan Africa have been overlooked. They proved that 67% of oil palm expansion from 2000 to 2015 occurred at the expense of forest in the Southwest region of Cameroon.

Coincidentally, these are priority areas often safeguarded by the policies of the World Bank and the African Development Bank (ADB), because they are elements of the natural heritage of a country.

3.1.5 Soils and water pollution

Water samples were collected upstream, at the spillway and downstream of the palm oil extraction sites in Ngwéi and Ekondo Titi. Chemical and bacteriological analyses were carried out on 09 water samples. The results revealed contamination and pollution, including even groundwater. Overall the surface waters analyzed are basic with pH values all above the recommendations of the WHO standard for drinking water. Chemical oxygen demands are high and reflect pollution. Suspended matters are present in all samples. In addition, two Ekondo-Titi samples have concentrations of ammonium (NH4 +) ions relatively higher than the recommended value (≤0.50). At the microbiological level, six (06) samples showed concentrations of fecal coliforms not complying with guideline values (0UFC/100 ml). As a result, these waters would be under the influence of a major source of pollution, making them unfit for human consumption without prior treatment. Well water and groundwater are also contaminated.

Component of the affected environment	Activities sources of impacts	Impacts	Characterization parameters and rafting						Final assessment
			Nature	Occurrence	Intensity	Spatial extent	Duration	Reversibility	Importance
Air	Land clearing/ deforestation Storage & preparation of nut Oil extraction	Degradation of air quality	▼	3	2	1	1	2	1,8
Surface water	Land clearing/ deforestation Oil extraction Waste management	Degradation of water quality / contamination, pollution	▼	3	3	4	4	4	3,6
Underground water	Land clearing/ deforestation Oil extraction Storage & preparation of nut	Contamination, water table attack, pollution	▼	3	2	1	3	3	2,4
Soil	Land clearing/ deforestation Staking, hole punching Planting Storage & preparation of nut Oil extraction	Degradation of soil quality Contamination, pollution	▼	4	4	2	3	4	3,8
Naturel habitat	Land clearing/ deforestation Staking, hole punching	Fragmentation, destruction of natural habitats	▼	3	3	4	5	5	4

Component of the affected environment	Activities sources of impacts	Impacts	Characterization parameters and rafting						Final assessment
			Nature	Occurrence	Intensity	Spatial extent	Duration	Reversibility	Importance
Flora	Land clearing/ deforestation Plant maintenance Harvesting bunch Felling old palm plants	Deforestation, fragmentation	▼	5	5	4	5	4	4,6
Fauna	Land clearing/ deforestation Staking, hole punching Plant maintenance	Fauna habitat disturbance Migration and loss of fauna species	▼	4	3	3	5	5	4
Non-timber forest products (NTFPs)	Felling old palm plants	Increase /decrease in NTFPs Loss of medicinal species	▲▼	3	2	2	5	5	3,4

Source: fieldwork, 2016–2020.

Table 8.
Absolute importance of the impacts of the oil palm cultivation on the biophysical milieu.

Also, field surveys show that waste oils emanating from SOCAPALM and PAMOL mills flow into rivers and streams close to village dwellings. These rivers and streams remain the most fishing and living places estimated by local populations (consumption, bathing, etc.). As a result of these liquid waste, local populations are not only deprived of much of their fishing resources, but they are also exposed to health risks. Another negative aspect is the environmental impact of artisanal mill units whose process is polluting because the discharges are not treated. Finally, deforestation exposes the soil surface and accentuates its leaching. The oil palm plantation establishment modifies the soil texture as well as its biological characteristics, which is often partly responsible for the degradation of plant diversity in oil palm plantations. This degradation of soil quality is at the origin of the loss/fragmentation of the wildlife natural habitat as well as the destruction of the soil micro-fauna.

Unfortunately, the issue in water and soil pollution, is the mostly poor assessed aspects in many studies. However, greenhouse gas emissions occur from mill and plantation activities, and especially from Palm Oil Mill Effluent (POME), a liquid waste from the initial processing of fresh fruit bunches. Little is known about the pollution of waterways by fertilizers, pesticides and other chemicals used in oil palm plantations, as well as their impact on human health, aquatic species and fisheries [21]. Qaim et al., [29] found that forest conversion to oil palm plantations also affects ecosystem functions. Among others, the functions affected include carbon storage, nutrient cycles, soil regeneration, and air and water purification. Releasing POME into waterways harms aquatic ecosystems by creating highly acidic environments or causing eutrophication and this is in line with our results.

Landscapes dynamics have been assessed through the populations rating. The synthesis is shown by **Table 9** interpreted the lines after.

The high score (34.62) for the "slow increase" trend in Ekondo Titi reflects the illusion of the population's margin for maneuvering the resources of their territory (sea, Atlantic forest, dense forest and mangrove) in Ekondo-Titi. It is worth mentioning that the fallacy of the people of Ngwéi and Sanaga Maritime, of whom approximately 2/5 believe that the landscape has not changed (43.20 & 40.75). However, they objectively acknowledge (23.4 & 22.57%) that negative changes (landscape degradation, resource depletion, poverty) are more significant than positive changes (15.4 & 18.15%). This means forest depletion is a reality even though if people succeed in getting a cash benefit from oil palm activities.

3.2 Economic impacts of oil palm

In Sanaga Maritime, 51% of the population admitted that oil palm enable them to validly meet their existential needs [5]. For the elite, this is a sector where people

Area	**↑ steep upward**	**↗ slow increase**	**→ no change**	**↘ slow decrease**	**↓steep downward**	**Total**
% synthesis Ekondo Titi	*16.15*	*34.62*	*28.85*	*13.85*	*6.54*	*100*
% synthesis Ngwéi	*8.2*	*15.4*	*43.2*	*23.4*	*9.8*	*100*
% synthesis Sanaga Maritime	9.25	18.15	40.75	22.57	9.28	100
Mean Total	**11.2**	**22.72**	**37.6**	**19.94**	**8.54**	**100**

Table 9.
Landscapes trend arrows and scores in Ekondo-Titi, Ngwéi and Sanaga Maritime.

invest to earn extra income or prepare for retirement. In the elaeisfarming areas of Cameroon, an abundance of direct or indirect activities linked to this sector makes it possible to more or less effectively rule out the specter of unemployment and poverty. In terms of employment and the local economy, results show that oil palm has a positive impact with scores ranking from 3.6 to 4 despite its overwhelming negative biophysical impact (**Table 10**).

Jobs and revenues generated by the various activities related to the establishment, maintenance and operation of a palm plantation (planting and plant maintenance, transport of FFB and oil extraction) constitute the most visible face of its socio-economic impacts able to boost the local economy if the sustainability conditions are fulfilled. Several aspects of this positive impact are to be noticed (1): the sale of FFB by farmers and elites to agro-industries; (2) the establishment of modern mills; (3) Significant induced impacts linked to a flowering of secondary processing industries in Cameroon (soap factories, cosmetics); (4) The sale of artisanally or semi-mechanically extracted oil to soap factories, on local and regional markets or at the roadside; (5) the development of income-generating activities and petty trade in these villages thanks to the oil palm cultivation; and (6) the development of cooperatives based on existing CIGs will constitute the final stage of this economic facet observed in both districts. The population perception is resumed in **Table 11**. One can observe better results in income level, Job creation and welfare while quality of social network and social infrastructure remain lukewarm.

From an economic standpoint, the benefits of oil palm cultivation are undeniable. This profitability explains the rapid development of the "red gold". Nevertheless, the contribution of the palm plantation to the local economy and to the well-being of neighboring populations does not always meet expectations. The benefits for the national economy must also be optimized. Palm oil being a source of financial evasion, it is necessary to ensure the autonomy of Cameroon in order, as much as possible, to avoid imports.

On the economic point of view, **palm oil appears as one of the most profitable land uses in the tropics because for the most producing countries, it significantly contributes to the national economies and to reduce poverty elsewhere in the producing countries** at local, regional, and national levels [30–33]. In the main producing countries like Malaysia and Indonesia, oil palm accounts for 10% of total national exports and 44% of world palm oil exports. This data is reduce by half in several smaller producing countries, such as Honduras, Papua New Guinea, Solomon Islands, and Guatemala, palm oil exports account for around 5% of total national exports [28]. This explains why oil palm generates higher incomes than rubber or cocoa and other commodities, which occupy a prominent place in exports. Cocoa, for example, represents 15% of Côte d'Ivoire's GDP and 40% of merchandise exports [34]. These laudatory results (at the economic level) are obtained mainly thanks to a cash crop organized and carried out with methods which give absolute priority to the best yields. Most of these authors show that small farmers are the most beneficial of the boom of oil palm worldwide [22, 26–28]. Despite contradictions on assessment of this economic effects of oil palm, it is evident that elaeis farming has improved incomes for rural people and supported the development of rural economies and the economies of producer countries overall.

3.3 Social impacts in the oil palm sector in Cameroon

As observed on the field, social impacts must include social protection, collective bargaining, inclusive dialogue, conflict resolution, health risk, corporate social responsibility and environmental justice. These questions variably challenge the

Component of the affected environment	Activities sources of impacts	Impacts	Characterization parameters and rafting						Final assessment
			Nature	Occurrence	Intensity	Spatial extent	Duration	Reversibility	Importance
Local economy	Harvesting bunch Packaging and sale	Development of economic activities Increase in income	▲	3	3	3	5	4	3, 6
Employment And income level	Land clearing/ deforestation Staking, hole punching Planting Plants maintenance Storage & preparation of nut Oil extraction Packaging and sale	Job creation	▲	4	4	5	4	3	4

Source: fieldwork, 2016–2020.

Table 10.
Absolute importance of impacts of the oil palm on the economy.

Area	**Sanaga Maritime (n = 335)**			**Ngwéi (n = 290)**			**Ekondo-Titi (n = 260)**		
Variable	**N**	**No change**	**P**	**N**	**No change**	**P**	**N**	**No change**	**P**
Income level	15	10	75	13	8	79	10	9	81
Quality of social network	25	10	65	27	5	68	15	10	75
Job creation	5	15	85	7	5	88	5	5	90
Social infrastructure	45	35	20	55	25	20	55	30	25
Welfare	10	10	80	5	5	90	4	6	90

Table 11.
Perception of livelihood economic impacts through questionnaire and landscape methods.

agro-industrial and artisanal sub-sectors. In the wake of agro-industrial activities (SOCAPALM, SAFACAM, CDC, PAMOL), more or less, there is a slight satisfaction with the social protection of employees even if controversies regularly emerge on related issues, for example at the level of wages. The fact remains that the latter are regularly paid and for the most part and benefit from some social security. Conversely, almost all of these agro-industrial companies do not adapt well to syndicate activities, especially when tackling economically sensitive issues such as salary increases, health care, paid leave, security, social benefits of family members of employees, etc. Dictatorship and dismissal are common practices without any prospects for inclusive dialogue and concerted negotiation within companies. The social situation between the owners of the elite palm plantations and the local populations is tense at Ngwéi. Because the impacts are so important (**Table 12**), it is necessary to give sustainable compensation to populations whose land has been occupied by agro-industries in the expected standards. One can add the fact that the health risk is high in agro-industries because health infrastructures are under-equipped and obsolete. The housing conditions of workers are deplorable with overpopulation, dilapidated camps, non-functional water pumps, frequency of energy power cuts, etc.

Over the 83 impacts of the table, 37.35% are positive while 62.65% are negative signifying that on social domain, oil palm can be seen as a threat. Thus, the social and economic impacts of oil palm cultivation are numerous and sometimes contradictory. It may be overshadowed by the employment and income impacts, but the social consequences of this activity remain numerous.

In the field of the artisanal sub-sector, local populations working in oil production sites take no measures to protect their health. The gloomy observations draw by such a situation are: disorganization of the sector and the market, lack of social security for smallholders, land disputes, conflicts with agro-industries (**Table 12**), lack of personal protective equipment against heat & smell, etc. The question is that of a sector that will be fully organized, where the players remain scattered and whose activities sufficiently demonstrate a collective lack of consideration of social sustainability.

The oil palm provides local communities with many material, social and cultural uses ranging from food to traditional pharmacopoeia through decoration and construction materials, contributing to their well-being and their socio-cultural development. For the traditional pharmacopoeia, red palm oil is an antidote to poisons, palm kernel oil is useful for skin care in both new-borns and adults. Lastly, palm wine appears inescapable in all traditional ceremonies and rites concerning enthronement, weddings, deaths and funerals.

Component of the affected environment	Activities sources of impacts -	Impacts	Characterization parameters						Final assessment
			Nature	Occurrence	Intensity	Spatial extent	Duration	Reversibility	Importance
Conflicts	Plant Care Storage and preparation of palm nuts Fruit bunches harvest Packaging and sales	Land dispute, Agression, violence Intimidation, threat Tense social climate	▼	4	4	1	4	2	3
Human health	Plant Care Storage and preparation of palm nuts	Degradation of workers human health of injury	▼	4	3	2	4	2	3
Insecurity	Plant Care Storage and preparation of palm nuts	Injuries Food deficit, social conflicts		3	3	2	3	3	2.8
Noise	Storage and preparation of palm nuts	Noise	▼	3	2	2	2	1	2
Odour	Storage and preparation of palm nuts Waste management	Degradation of air quality	▼	3	2	2	1	1	1.8
Cultural heritage	Craft production of palm kernel oil	Traditional Pharmacopoeia		3	3	5	4	3	3.6
Landscape aesthetics	Creation of new nurseries	Landscape embellishing	▲	2	2	1	1	1	1.4

Source: fieldwork, 2016–2020.

Table 12.
Absolute importance of impacts of the oil palm on the social environment.

Insecurity impacts can be perceived from many angles: bodily risks, lack of safety measures and injuries and accidents' risks during clearing, hole digging, cleaning and maintenance of the palm plantation; and above all, oil palm harvesting and the pruning of the palm trees. Food insecurity is caused by low consideration in subsistence or food crops for the benefit of oil palm. Food production have decreased for almost 45, 55 and 57% of the respondents in Ngwéi, Ekondo Titi and Sanaga Maritime. There are also, land tenure (97% in Ngwéi and Sanaga Maritime and 74% in Ekondo-titi) and water resources conflicts among smallholders' farmers as well as between them and hunters.

Finally, cumulative impacts (physical and human environment) affect habitat fragmentation, degradation and loss of biodiversity, deforestation coupled with the rubber and cocoa single-crop farming or the merchant crop including plantain; food insecurity; social conflicts; social protection and collective bargaining. The population perception, shown in **Table 13**, revealed relative better access to food and social infrastructure, increase in quality of housing and better access to drinking water (due to the multiplication of drilling), but significative increase in water pollution as well as insecurity and conflicts.

At the socioeconomic level, there are enormous discrepancies depending on the category of actor. The oil palm value chain seems in fact to benefit more to agro-industrial actors and operators of second and third palm oil transformations. On the contrary, smallholders, because they are not sufficiently taken into account in sectorial policies, are poorly organized, which does not allow them to take the best advantage of the still artisanal oil palm exploitation. The quantitative economic numbers therefore drown the realities.

Socially, the results above demonstrated many negative externalities, thus raising the issue of many social impacts that many authors have addressed. Is palm oil a driver of development or a driver of inequality? [7]. Because almost 70% of the elaeisfarming areas belong to Asian or European firms, Bouron [7] considered oil plantation as "the archetype of the large capitalist plantation". Indeed, the proportion of palm oil produced by smallholders has steadily increased in Cameroon from 10 to 26% today. In Indonesia and Malaysia, smallholders account for roughly 40% of the total area of planted oil palm and as much as 33% of the output, due to lower yields, on average. There is significant variation in the way that smallholder oil palm cultivation is organized [22]. It is clear that almost 50% of the oil palm land is managed by smallholders worldwide [28]. Though, it is known that oil palm is profitable for rural households and communities in terms of new

Area	**Sanaga Maritime (n = 335)**			**Ngwéi (n = 290)**			**Ekondo-Titi (n = 260)**		
Variable	**N**	**No change**	**P**	**N**	**No change**	**P**	**N**	**No change**	**P**
Access to food	45	20	35	50	20	30	60	15	25
Quality of Housing	12	18	70	10	15	75	20	15	65
Access to land	22	10	68	12	16	72	5	15	80
Access to social infrastructure	50	10	40	50	15	35	40	15	45
Access to drinking water	20	8	72	12	10	78	38	12	50
Water pollution	68	20	12	72	18	10	70	15	15
Insecurity and conflicts	75	10	15	83	10	7	85	5	10

Table 13.
Perception of livelihood social impacts through questionnaire and landscape methods.

employment and opportunities, farm profits, and improved rural infrastructure [28, 32, 35]. Nevertheless, this profit is not to be applied to all households and communities [36]. There are many new jobs and employment created by oil palm for landless laborers and rural households in Indonesia, in Mexico and Guatemala [37]. For some countries like Ghana and Guinea, there is a relative stable incomes and higher levels of food security [30, 38]. Migrations is another aspect underlined by [39]. Despite, employment, jobs, rural migrations, wage incomes, linked to the palm oil sector, it does not necessarily improve welfare in terms of food security, and other non-income dimensions, land conflicts, [7, 40, 41],

Some of the negative social consequences of this "oil rush" include land grabbing, large deforestation and the spoliation of indigenous peoples land rights together with unclear land property rights and laws [7, 28, 42, 43] by the large corporations and agro industries. Moreover, the educational level and financial capacities of these agro industries and corporations are also clearly higher than those of the "average" peasants, allowing them not only all the imaginable corruptive drifts (towards the administration, the traditional chiefs) but, above all, giving them an advantage in negotiation [16]. Notwithstanding efforts in developing and implementing forest protection measures, progress has been weak towards achieving this sustained goal and alleviates poverty. This has resulted in Cameroon maintaining palm oil exploitation close to protected areas. The desirability of future agricultural land to be conquered outweighs the desire to cover the forests still standing. According to data from the World Bank [44], Indonesia only granted protected area status to 12% of its vast territory, behind other comparable countries such as the DRC (13.8%) or Colombia (14.8%) and far behind Brazil (29.4%). Malaysia does better with 19.1%. In Cameroon, almost 25% of the territory is devoted to protected areas. But, the government policy can mask a great diversity of situations on the ground. Thus, the State granted 15,000 ha to Greenfil agro industry in 2014 and 50 000 ha to Camvert in 2019 near protected areas of HCV forest while de-gazetted FMU 09–025.

Such a situation shows not only the poor forest and land governance, but also, the weakness of the means of control which leads to illegal clearing, including within protected areas [45].

3.4 Institutional impacts

Outside the national framework, publics institutions seems not adapt to the local context of oil palm cultivation. Smallholder's access to land is not guarantee. This lack of good governance is a treat that can't favor sustainability of the whole sector. In addition, securing the elaeisfarming basins, prey to attacks by armed groups, is also seen as a necessity for Cameroon. An integrated and sustainable management approach in the oil palm sector takes into account all stakeholders. Governance requires having at least a national oil palm strategy still awaiting, then fighting against deforestation, approving selling prices, rationalizing production and reducing imports. Cameroon has a national strategy for sustainable development of the palm oil sector which is pending validation. This strategy identifies a set of actors and hierarchical decision-making bodies for the governance of the sector. The national steering committee is responsible for monitoring the implementation of the strategy. To this body, one can add programs and projects, professional organizations (inter-professional organizations, cooperatives and unions), consular chambers and national and regional consultation frameworks.

Overall, this analysis summarizes direct, indirect and cumulative impacts. **The direct impacts on the biophysical environment are:** air contamination, olfactory pollution, ground and surface water contamination/pollution, soil contamination

and pollution, flora and fauna destruction, biodiversity degradation, deforestation and forest conversion, reduction of NTFPs and landscape aesthetics**. The direct impacts on the human environment can be summarized as:** employment and income, local economy, human health, insecurity and conflict, noise, odours, cultural heritage and waste. **Indirect impacts (physical and human)** include habitat fragmentation, degradation and loss of biodiversity, food insecurity, cultural heritage, social protection, collective bargaining and local crafts. **To end, cumulative impacts (physical and human environment)** affect habitat fragmentation, degradation and loss of biodiversity, deforestation coupled with the rubber and cocoa single-crop farming or the merchant crop including plantain; food insecurity; social conflicts; social protection and collective bargaining.

Institutional impacts are the most neglected aspects of the oil palm governance in African countries. First of all, very few countries have legislation specifically related to forest degradation and land use change and the government gives privilege on land to foreign investors and agro industries being local and not [20]. Unfortunately, without appropriate policies, smallholder production is not necessarily more rainforest-preserving, as smallholders are also significantly involved in deforestation [25, 33]. Strategies that aim at including smallholders in palm oil need to take into account: securing of land titles, access to credit, and technical support while accounting for the existing heterogeneity [46, 47]. Djouma et al. [48] propose a win-win partnerships between agro-industries and smallholders to boost the development of the national palm oil sector. Meijaard et al. [26] emphasize on certification as it is the case in Malaysia an Indonesia while African countries could not. But it is true that high carbon stock and high conservation value approaches are part of international concerns related to deforestation and oil palm environmental impacts [26, 45].

Finally, how to produce while limiting negative externalities as much as possible, one can ask? The answer can be found on several international programs launched for many agricultural crops taken individually or in groups. In the cocoa sector, for example, there are ISO 34101 standards for a sustainable and traceable cocoa bean [49]. To these initiatives must be added the certifications (like RSPO, Global Gap, Fairtrade, etc.) which give advantages on the market to producers respecting certain sustainability rules [21, 50].

4. Conclusion

The objective of this article was to assess the environmental impacts of the palm oil sector in Cameroon. The methods used gathered field observations, satellite images processing and participative survey among population through landscape perception methods. Three main production basins (Sanaga Maritime, Littoral and Southwest) were chosen.

The results revealed that the oil palm cultivation has many negative consequences on the environment such as deforestation and various forms of pollution. On deforestation Ngwéi account for 45.94% in 40 years (i.e. 1.20% per year), Sanaga Maritime, 23.61% (i.e. 0.87% yearly) and Ekondo-Titi, 22.74% (0.61% per year). The perception of rural populations confirms the results obtained on deforestation with 44.5, 33.6 and 20.39 in Sanaga Maritime, Ngwéi and Ekondo Titi respectively. The same with animal biodiversity which gave 65.81%, 47.54% and 58.53% in Sanaga Maritime, Ngwéi and Ekondo Titi respectively. Ecological impact in the matrix is 96.5% negative against 3.5 positive. The biodiversity declines and Simpson index are low in area of oil palm plantations than in other with 0.20–0.21 for Shannon index against 0.01–0.02 for Simpson index.

Economically, the sector is still dominated by small producers whose methods significantly impaired profitability. Economic impacts are 51% positive and the score varies by items with 75%, 79 and 81 for income in the Sanaga Maritime, Ngwéi and Ekondo Titi respectively; 95, 88 and 90% for Job in Sanaga Maritime, Ngwéi and Ekondo Titi respectively, also 80, 90 and 90% in Sanaga Maritime, Ngwéi and Ekondo Titi respectively for welfare.

Social impacts are diverse with 37.35% overall impacts positive against 62.65% negative. In social way, only housing (70, 75 and 65%,) access to water (72, 78 and 50) access to land (68, 72 and 80) for Sanaga Maritime, Ngwéi and Ekondo Titi respectively are 45, 50 and 60) and water pollution (68, 72 and 70) insecurity and conflicts (75, 83, 85%) are negative. At the social level, wage employment in the field is not well organized and corporate social responsibility is not applied among agro-industries and other large farmers (elites) who nevertheless deserve to be encouraged in this direction if we want to give the local riparian populations the opportunity to benefit from it.

At institutional level, governance is not well perceived apart from policies proposed to increase smallholders' areas under cultivation.

The above results revealed that the main objective of the research were fulfilled. The novelty brought by the present study lays on the effort to involve populations in the participatory assessment of their oil palm growing landscape in order to better understand the issues. Also analyzing water pollution that have not really encountered in the documents consulted. The study has equally focused on the impacts of the institutional side, little criticized in previous research in Africa, because the laws on the land are enacted by the governments which do not often hold the customary laws of the populations who are the first occupants of these territories. Indeed, already poorly organized, they are not sufficiently taken into account in sectorial policies. With regard to the environment or more specifically ecology, it is necessary to limit deforestation and the pollution induced by the palm oil sector through energetic measures, because we are witnessing a permanent granting of concessions (Greenfil SA allotted in 2014 and CAMVERT in 2019) for oil palm despite warnings and actions from environmental organizations like WWF and Rainforest. Also, it becomes necessary to respect the sustainability values, improve the agricultural yields and the livelihood, contribute to local development, and protect High Conservation Value (HCV) areas around the oil palm belt as well as preserving the environment.

Methodologically, the techniques used (transects and quadrates for biodiversity assessment, carbon assessment, remote sensing, landscape approach) without forgetting the surveys carried out with 40 students in the field made it possible to familiarize them with the impacts practices. A database has been established on the socioeconomic determinants of oil palm. In addition, the populations were made aware of how to take their landscape into account and questions of spatial justice.

The limitation aspects of this study rely on the links between climate change and oil palm plantations which have been little addressed. The same is true of the systematic census of animal species in oil palm cultivation areas. Nevertheless, the high academic contributions of the study is linked to multidisciplinary team invested (biologist, botanist, agronomist, ecologist, geographer, economist) to lead to the understanding of the socio-spatial and socio-economic and ecological changes that have occurred in Cameroon for about 30 years. The team was able to articulate questions of environmental and climatic spatial justice (subject of a current thesis) and validate the theory of the anthropocene. Practically, the impact analysis carried out reveals the need to review cultivation techniques and even agricultural policies in Cameroon, particularly the national oil palm strategy, which

stills pending. A special attention is to be paid to several aspects of land management methods, availability of seeds and plant material, technical support for small growers, and awareness of the challenges of sustainable development and biodiversity conservation.

Author details

Tchindjang Mesmin[1*], Ludovic Miaro III [2], Fideline Mboringong[3], Gilles Etoga[3], Eric Voundi[1] and Emmanuel Pierre Jonathan Ngom[4]

1 Department of Geography, The University of Yaoundé 1, Yaoundé, Cameroon

2 Regional Food System & Green Growth, WWF ROA Yaoundé Hub - Panda House, Yaoundé, Cameroon

3 WWF ROA Yaoundé Hub - Panda House, Yaoundé, Cameroon

4 Ministry of Agriculture and Rural Development (MINADER), Yaoundé, Cameroon

*Address all correspondence to: mtchind@yahoo.fr; tchindjang.mesmin@gmail.com

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