ISSN No : -2456-2165 https://doi.org/10.38124/ijisrt/26may1032

Black Gold in the Bongor Basin in Chad: The Impact of the Decline in Agricultural Activity

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Publication Date : 2026/06/03

Abstract: Since independence, agriculture has been the cornerstone of the Chadian economy and the primary source of employment. However, in an effort to address the fragility of this sector and diversify economic resources, Chad has decided to exploit its mineral reserves. It is within this context that the Bongor Basin alone hosts some of the most heavily exploited oil fields in the country. This article aims to examine the effects of this oil activity on the agricultural development of the area. The resulting hypothesis is that the growth of oil activities is a factor in the decline of agriculture in the region. The methodology used to test this hypothesis relied on remote sensing, which allowed researchers to observe changes in land use. We also collected data on the evolution of agricultural production through documentary research with the Ministries of Mines and Agriculture, and the National Agency for Rural Development Support (ANADER). Fieldwork was conducted using interviews, focus groups, and questionnaires administered in the study area to gain a thorough understanding of the realities related to the availability of arable land, labor, and the proliferation of oil wells in agricultural zones.

Keywords*: Bongor Basin, Oil Exploitation, Recession, Agricultural Activity, Chad.*

How to Cite : Varga David ; Abbaye Tchemsala Prosper ; Pr Obono Mba Félicité (2026) Black Gold in the Bongor Basin in Chad : The Impact of the Decline in Agricultural Activity. *International Journal of Innovative Science and Research Technology*, 11(5), 2932-2942. https://doi.org/10.38124/ijisrt/26may1032

I. INTRODUCTION

In developing countries, agriculture remains a fundamental activity for food security and the socio-economic well-being of rural populations. In Chad, this sector has been the pillar of the national economy and the main source of employment since independence.

The Bongor Basin, located in southern Chad and comprising the administrative entities of Chari-Baguirmi (Loug-Chari) and Mayo-Kebbi East (Koudalwa), is an area with a strong agro-pastoral focus. It benefits from a hot and humid tropical climate with 800 to 1,200 mm of rainfall per year (Sama, 2003), Sudanian vegetation, and a flat landscape conducive to agricultural activities. Sorghum, millet, maize, cowpeas, pearl millet, cassava, yams, peanuts, sesame, and cotton are cultivated there. Livestock farming, particularly cattle farming, is also booming there.

However, since the early 2010s, the rise of oil exploitation in the Bongor Basin has profoundly transformed the territorial and productive dynamics of this area. The installation of oil infrastructure is accompanied by the progressive occupation of agricultural land, soil and water resource degradation, and a restructuring of the rural labor market. Several studies show that the introduction of extractive activities in rural areas often generates socio-economic and environmental imbalances, particularly when agriculture is the primary source of livelihood for the population.

Therefore, a central question arises: what are the effects of oil exploitation on agriculture in the Bongor Basin? This study aims to analyze these effects through the lens of agricultural land use, labor availability, natural resource degradation, and changes in agricultural production.

II. METHODOLOGY AND SPATIAL SCOPE OF THE STUDY

➢ *Methodological Approach*

Achieving the established objectives involved a combination of spatial analysis, literature review, and field surveys. For the spatial analysis, satellite images of the study area from 2011 and 2020 were used as the basis for analysis. A QuickBird image from Google Earth was also used to perform a spatial analysis of the area. Finally, to generate a land cover map, sensors from the Landsat satellite were selected.

Satellite imagery was supplemented with demographic data from the National Institute of Statistics, Economic and Demographic Studies (INSEED), specifically the 2009 General Population and Housing Census (RGPH). This data was combined with agricultural data from the National Agency for Rural Development Support (ANADER), which allowed for the study of changes in farm size and agricultural

ISSN No : -2456-2165 https://doi.org/10.38124/ijisrt/26may1032

production. Data from the Directorate General of Mines of the Chadian Ministry of Industry and Mines were also used to track changes in the areas dedicated to oil wells in 2011 and 2019. Following this step, primary data collection was conducted with administrative and traditional authorities. To this end, we used focus group discussions with the populations of each locality to gain a deeper understanding of their realities. In total, eleven (11) focus groups were conducted with village chiefs and their elders, village communities, youth groups, and women's groups in the eleven (11) localities visited. Each focus group comprised at least eight (8) people.

We also administered a questionnaire to oil operators and farmers. For the oil operators, we randomly selected ten from each of the eight sites visited, bringing the total number of oil operators surveyed to 80 (Table 1). The selection of the ten operators to be interviewed per site took into account the different categories of activities carried out at the site, their age, and their gender, in order to determine their nationalities, their original professions, and their motivations.

Table.1 Distribution of Surveyed Oil Operators by Site

Sites	Number Famers Surveyed	Remarks
Ronier	10	Koudalwa
Memosa	10	Koudalwa
Daniella	10	Koudalwa
Raphia	10	Koudalwa
Baobab	10	Koudalwa
Lanea	10	Chari Baguirmi
Prosopis	10	Chari baguirmi
Moringa	10	Chari Baguirmi

Source : Enquêtes de Terrain, 2020

The survey of farmers was conducted throughout the localities of our study area. We randomly selected twenty farmers per village and ten per site, resulting in a total of 170 farmers interviewed, taking into account age, sex, and length of residence in the basin.

➢ *Spatial Framework of the Study*

The Grand Baobab deposits are located in the Bongor Basin, in the Chari-Baguirmi region, Loug-Chari department, in the Republic of Chad. The defined area covers a total surface area of approximately 176.25 km². This basin benefits from a hot and humid tropical climate with 800 to 1,200 mm of rainfall per year (Sama, 2003).

III. RESULTS

➢ *Colonization of Agricultural Land by Oil Activity*

The relatively high humidity of the Bongor Basin makes it an area conducive to agricultural expansion. The level of agricultural production in this basin has made it a high-yield agricultural zone (K.N. Kouadio, 2009, p. 5). Perennial and food crops are grown there. The dominant crops are sorghum, cowpeas, pearl millet, and maize, for which this area, along with Lake Chad, constituted a third pioneer front. It remains a concentration zone for sorghum, rice, cassava, yams, and maize as food crops, while cotton and peanuts are also produced as cash crops.

However, oil activity has seen a resurgence of interest there since 2011, with the opening of oil production under the auspices of the CNPCIC group. This activity has come at the expense of agricultural land. Oil exploitation, nonexistent before 2011, occupied 176.25 km² with the first operating permit issued in 2013. This area subsequently expanded with the second mining permit, on which the company operates 740 ha, bringing the total land occupied by oil exploitation to 1,600 ha, an increase of 54%. In addition to these officially recognized areas, there are also areas occupied by artisanal gold mining.

Analysis of satellite imagery reveals changes in land use before and during oil activity (Figure 2 – land use map, to be inserted). Two distinct phases can be identified in the evolution of sorghum cultivation areas.

The first phase, from 2006 to 2009, was marked by slow but positive growth in sorghum cultivation, with an increase of approximately 2.54%. This slight growth was due to the attractive prices offered by operators in the sector nationwide, with the farmgate price of sorghum maintained at 1,000 FCFA per kilogram, thus sustaining public interest in this crop.

The second phase, from 2009 to 2015, was characterized by a decrease in cultivated areas of approximately 26%. This decline reflects a gradual shift away from agricultural activities towards the oil industry, which simultaneously experienced a 10% expansion during the same period. This downward trend in agricultural land and upward trend in oil activity reveals the pull of the extractive economy on rural populations.

➢ *Agricultural Labor Shortage*

The development of oil activity in the basin is transforming the agricultural economic practices that have long governed the region's functioning. This transformation is resulting in the retraining of rural agricultural workers into oil sector employees.

Indeed, the existence of oil production has crystallized the hopes of young people, who envision their future only through activities related to this sector. The most highly skilled jobs require specific professional profiles that young

ISSN No : -2456-2165 https://doi.org/10.38124/ijisrt/26may1032

people in the area do not possess; they therefore turn to low-skilled jobs related to the oil company, which offers attractive levels of remuneration.

Since the start of the oil projects, the agricultural population, which in 1998 was estimated at 27,423 inhabitants (46% of the total population), fell to 6,856 inhabitants in 2014, representing 14% of the total population (INSEED, 2020). This downward trend in the agricultural population is explained by the economic attractiveness of the oil sector. Agricultural workers, whose average annual income ranged from 200,000 to 300,000 CFA francs, now find themselves in the oil sector with a daily wage of between 3,000 and 3,500 CFA francs for contract workers and a monthly income of 250,000 to 350,000 CFA francs for permanent employees.

This situation has led to a desire within the agricultural community to transition to the oil industry. This is the case for 40% of oil workers who identify as former agricultural workers, compared to 23% who work in both the oil and agricultural sectors. The attractiveness of the oil industry has also led to a surge in wages from workers who have remained loyal to agriculture: their labor is now valued at between 400,000 and even 500,000 CFA francs per year, compared to 150,000 to 200,000 CFA francs previously. This additional cost represents a burden that farmers cannot always afford.

- *Oil Activity As A Factor In The Destruction Of Natural Resources*

Oil production, like other extractive industries, is both a consumer of and a polluter of surface and groundwater resources. In the Bongor Basin, the presence of various types of oil fields has altered the water potential and soil structure. This degradation occurs through two main mechanisms: the discharge of byproducts from the processing stage and the leaching of exploited areas.

Extraction and processing techniques such as those practiced by CNPCIC generate discharges of heavy metals and toxic substances that contaminate neighboring farmland and the region's waterways. This pollution leads to an ecological imbalance that directly impacts agriculture. Groundwater contamination renders the soil not only polluted but also unsuitable for agricultural use. Furthermore, excavation and the removal of overburden result in the spread of dust that settles on vegetation, hindering its optimal growth.

These effects are confirmed by the testimonies of the farmers concerned: "My field is located 100 meters from the CNPCIC company's factory. The polluted water from the treatment stagnates for several months in my field and does not allow me to grow my crops."

- *Agricultural Production Marked by Losses*

The Bongor Basin, formerly a food and cash crop production area, has become, with the introduction of oil activity, an area of agricultural decline. This decline is manifested by a progressive reduction in arable land and the loss of agricultural labor, which combine to induce a structural decrease in local agricultural production (Figure 1).

Agriculture practiced in this area is extensive, meaning that production is directly proportional to the cultivated area. Consequently, any loss of agricultural land mechanically translates into a contraction of food production. The installation of oil wells in the basin has partially or totally expropriated approximately 150 farmers who were the original landowners. Even more significantly, the expansion of oil operations has necessitated the expropriation of more than 1,000 farmers. This double expropriation deprives farmers of their main source of income and livelihood, forcing them to buy on the market the food they previously produced. According to Abbaye (2020, p. 6), “44.4% of farmers who have lost part or all of their land buy food to meet their nutritional needs.” The food security of rural households in the basin is thus directly undermined by land dispossession.

Added to this land pressure is the effect of the demographic dynamics generated by oil activity. The influx of oil workers and their families increases local food demand, while local production decreases. This tension between decreasing supply and increasing demand fuels food price inflation, which traders from neighboring towns exploit by supplying the local market. This growing dependence on external trade weakens the food resilience of the basin, which was once self-sufficient.

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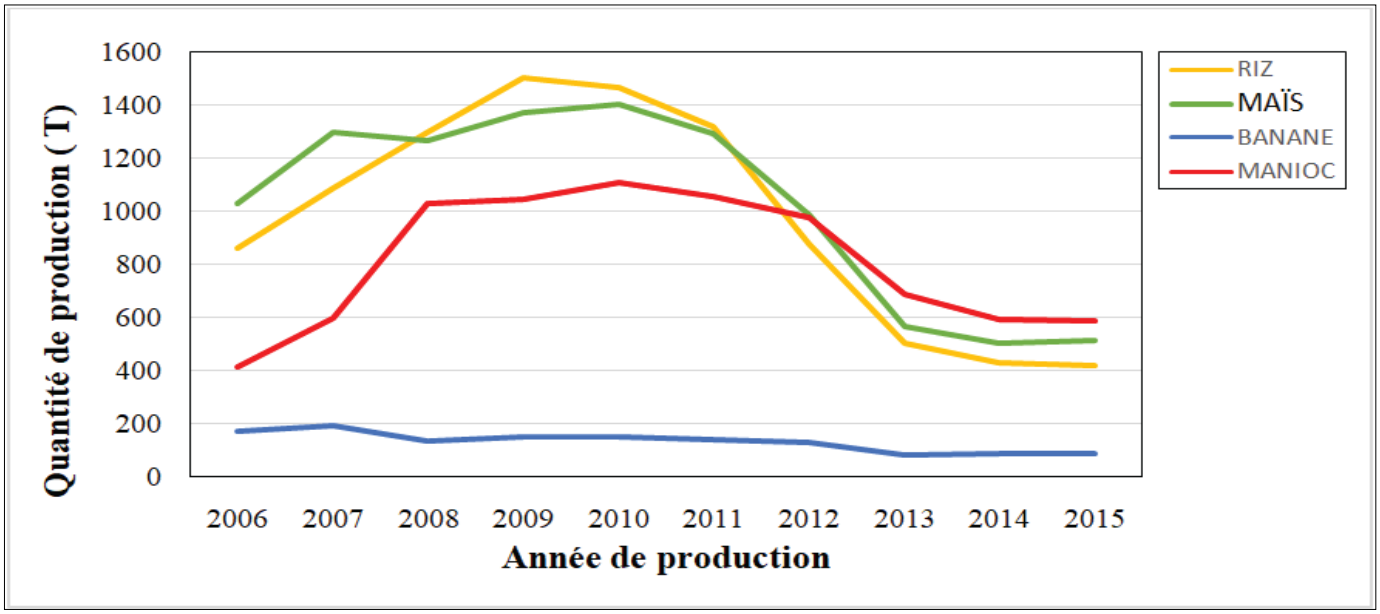

Fig 1 Trends in Food Crop Production from 2006 to 2015
Source : ANADER, 2016

Figure 1 reveals a general downward trend in food crop production in the Bongor Basin between 2006 and 2015. This trend is structured by three successive phases, reflecting the different stages of oil development in the local agricultural system.

The first phase, covering the period 2006-2008, is characterized by moderate growth in production. This positive trend corresponds to the initial installation of oil infrastructure in the basin, a phase during which agricultural settlements had not yet been relocated and agricultural work continued as normal. Farmers, not yet affected by expropriations, maintained their usual farming practices. This period can be considered the pre-disturbance stage, which will serve as a reference for measuring the extent of subsequent negative effects of oil exploitation (Lieugomg & Sama, 2007).

The second phase, from 2008 to 2011, corresponds to a plateau of stagnation in food production. This stagnation is explained by the progressive expansion of oil production, which generates two simultaneous effects: on the one hand, the blocking of new land clearing by the environmental moratorium and the expansion of oil fields; on the other hand, the beginning of a shortage of agricultural labor due to the retraining of workers for oil-related jobs. This stagnation actually represents a transitional phase between a still-functional agricultural sector and one in decline. Magrin (2001) documented this type of transition in other oil basins of Chad, emphasizing that agricultural stagnation generally precedes a phase of structural decline in extractive zones.

The third phase, from 2011 to 2015, is the most critical: it records a significant drop in the production of all food crops. This period coincides with the official delimitation of oil field moratorium zones by the Chadian government, which effectively placed vast agricultural areas beyond the reach of farmers. Food crops, grown mainly near homes and in the extraction zones, were the most directly affected by the opening of the oil fields. Added to this is the physicochemical degradation of the soils surrounding the wells, the impacts of which have led to reduced yields on the remaining plots. This phase eloquently illustrates what Thune (2011, p. 5) refers to as "the land encroachment of the oil site that makes it impossible to carry out the activities that previously exploited the soil and subsoil." It also corroborates Krueger's conclusions (1974, cited by Aknin, 2009, p. 17) on the threat that the pursuit of extractive rents poses to the economic development of rural areas.

Table 2(A) Statistique Descriptive Des Rendements Agricoles

	Number	Average	Ecart-type	Minimum	Maximum
Rain fall	11	1125,600	186,4462	860,6	1525,7
Maize	11	1,2491	0,24193	0,92	1,58
Cowpeas	11	1,0027	0,20528	0,81	1,42
Sorghum	11	1,2036	0,29466	0,98	2,00
fatgrass	11	0,9764	0,22146	0,80	1,60
Peanuts	11	0,8882	0,09304	0,75	0,99
Sesame	11	0,4964	0,10337	0,31	0,68
Cotton	11	1,0191	0,31265	0,80	1,60

ISSN No : -2456-2165 https://doi.org/10.38124/ijisrt/26may1032

- *Corrected Version*

Table 2(B) Descriptive Statistics of Agricultural Yields in the Bongor Basin (2009-2019)

Cropts/ Type	N	Average (t/ha)	Écart-Type	Minimum	Maximum
Rain fall (mm)	11	1 125,60	186,45	860,6	1 525,7
Maize	11	1,249	0,242	0,92	1,58
cowpeas	11	1,003	0,205	0,81	1,42
Sorghum	11	1,204	0,295	0,98	2,00
fatgrass	11	0,976	0,221	0,80	1,60
peanuts	11	0,888	0,093	0,75	0,99
Sesame	11	0,496	0,103	0,31	0,68
Cotton	11	1,019	0,313	0,80	1,60

Source : ANADER ; Calculs des Auteurs.

Analysis of the descriptive statistics in Table 2(A) & 2(B) reveals significant disparities between crops in terms of their average production level and interannual variability over the 2009-2019 period. Maize has the highest average yield (1.249 t/ha), followed by sorghum (1.204 t/ha) and cowpea (1.003 t/ha). Sesame has the lowest average yield in the series (0.496 t/ha), less than half the yield of maize. This hierarchy reflects both the soil and climate suitability of the basin for each crop and their differential sensitivity to disturbances induced by oil activity.

Examination of the coefficients of variation—calculated as the ratio between the standard deviation and the mean—reveals high interannual instability for cotton (CV = 30.7%) and sorghum (CV = 24.5%), crops whose yields are the most sensitive to variations in production conditions. This instability is particularly concerning in a context where disturbances are both climatic (rainfall variability between 860.6 mm and 1,525.7 mm) and anthropogenic (effects of oil exploitation). In contrast, groundnuts exhibit the lowest coefficient of variation (CV = 10.5%), indicating relative yield stability around the average. This lower variability is explained by groundnuts' relative resistance to drought and their short growing cycle, which gives them a greater capacity to adapt to seasonal fluctuations. Rainfall, with a standard deviation of 186.45 mm and an average of 1,125.60 mm (CV = 16.6%), confirms moderate but not negligible interannual variability. This rainfall variability constitutes a fundamental factor that compounds the effects of oil exploitation, making it difficult to attribute yield variations to a single cause. It is precisely to disentangle these cross-effects that Pearson correlation analysis was used.

Table 3 Pearson Correlations of Agricultural Yields, Oil Activities, and Rainfall

		Rainfall	Maize	Cowpeas	Sorghum	Fatgrass	Peanuts	Sesame	Cotton
Rainfall	Correlation de Pearson	1	,083	,398	-,302	,176	,268	,240	-,169
	Sig. (bilatérale)		,808	,226	,367	,604	,426	,477	,620
Maize	Correlation de Pearson	,083	1	,693*	,582	,670*	,874**	,771**	,742**
	Sig. (bilaterale)	,808		,018	,061	,024	,000	,005	,009
Cowpeas	Correlation de Pearson	,398	,693*	1	-,005	,497	,785**	,624*	,506
	Sig. (bilaterale)	,226	,018		,988	,120	,004	,040	,112
Sorghum	Correlation de Pearson	-,302	,582	-,005	1	,100	,368	,187	,149
	Sig. (bilatérale)	,367	,061	,988		,770	,266	,582	,662
Fatgrass	Correlation de Pearson	,176	,670*	,497	,100	1	,593	,681*	,692*
	Sig. (bilaterale)	,604	,024	,120	,770		,054	,021	,018
Peanuts	Correlation de Pearson	,268	,874**	,785**	,368	,593	1	,852**	,597
	Sig. (bilaterale)	,426	,000	,004	,266	,054		,001	,053
Sesame	Correlation de Pearson	,240	,771**	,624*	,187	,681*	,852**	1	,649*
	Sig. (bilaterale)	,477	,005	,040	,582	,021	,001		,031
Cotton	Correlation de Pearson	-,169	,742**	,506	,149	,692*	,597	,649*	1
	Sig. (bilaterale)	,620	,009	,112	,662	,018	,053	,031	
The correlation is significant at the 0.05 level (two-sided).									
The correlation is significant at the 0.01 level (two-sided).									

The Pearson correlation table highlights statistically significant associations at the 0.05 and 0.01 levels between agricultural yields, oil activities, and annual rainfall. These results confirm the existence of a structural link between the expansion of oil production and the decline in agricultural performance in the Bongor Basin, while also underscoring the modulating role of climate variability.

The positive and significant correlations between agricultural yields and rainfall ($r > 0$, $p < 0.05$ for most crops) confirm the dependence of rainfed production systems on

ISSN No : -2456-2165 https://doi.org/10.38124/ijisrt/26may1032

precipitation. In a Sudanian climate with two contrasting seasons, such as that of the Bongor Basin, rainfall variability is a major determinant of agricultural yields. This relationship is well documented in the Sudanian-Sahelian zone (Dardel et al., 2014). However, the significant negative correlation between the expansion of oil activities and agricultural yields ($r < 0$, $p < 0.01$) indicates a depressive effect of oil exploitation on agricultural production, independent of rainfall variations. This effect stems from land expropriations, labor shortages, and soil and water degradation caused by industrial activities.

These results are consistent with the work of Lieugomg & Sama (2007) in the Bébédjia area, which showed that the expansion of oil infrastructure in southern Chad

This leads to a systematic decline in agricultural land area and yields. They also confirm the findings of Koulro-Bézo (2001) regarding the impact of the Doba oil project on local agriculture. The convergence of statistical results and qualitative field analyses reinforces the strength of this study's conclusions on the reality of the negative impact of oil exploitation on agriculture in the Bongor basin.

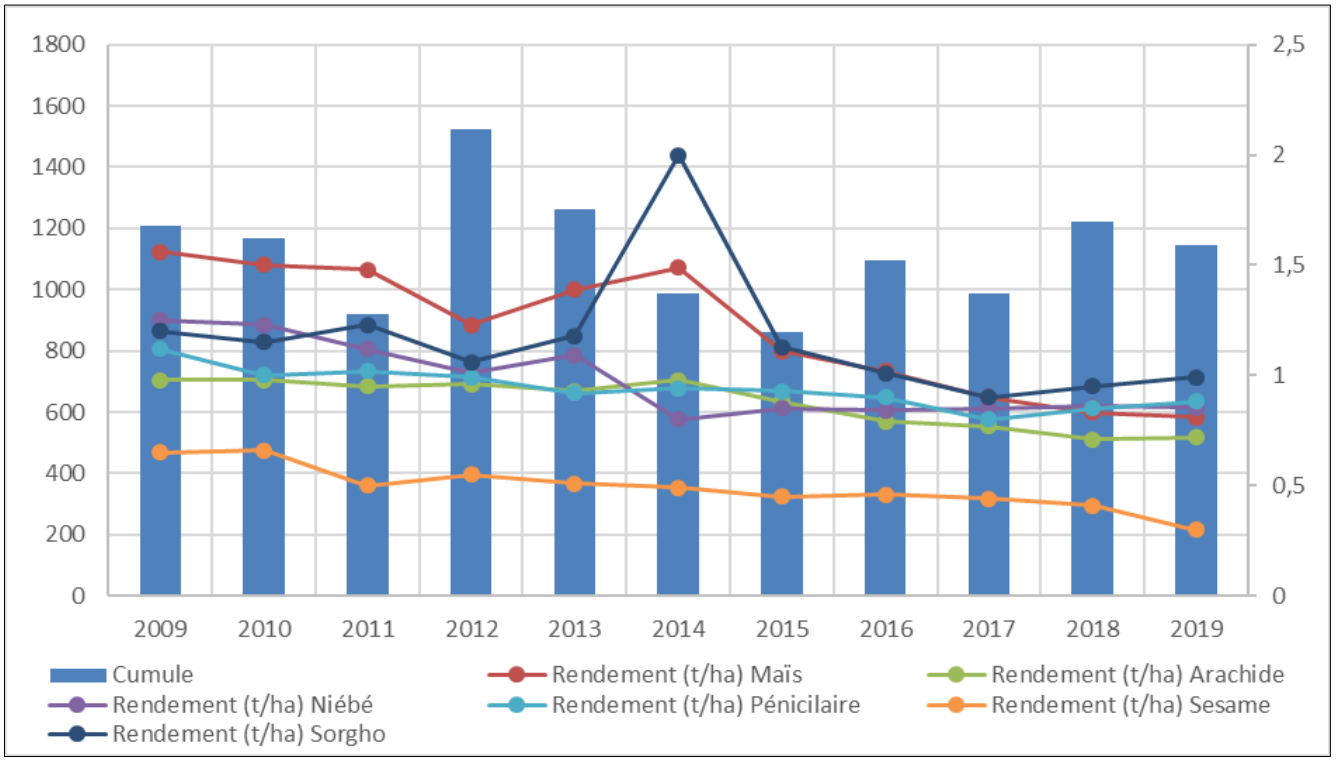

Fig 2 Variation in Agricultural Yields and Annual Rainfall
Analysis Results, Tchemsala Abbey, December 2020

The summary figure showing the variation in agricultural yields in relation to cumulative rainfall from 2009 to 2019 confirms the complex nature of the determinants of agricultural production in the Bongor basin. The curves reveal non-homogeneous trajectories among the different crops, reflecting varying sensitivities to disruptive factors.

It is observed that interannual variations in yields do not systematically follow rainfall fluctuations, which corroborates the results of Pearson correlations. Some years of good rainfall did not produce the expected yield gains, particularly after 2011, suggesting that non-climatic factors, specifically oil expansion, neutralized the beneficial effects of rainfall. This dissociation between water availability and production levels is a clear indicator of the disruption of agricultural production conditions by extractive activity. It illustrates what Magrin (2001, p. 312) describes as the "destructuring of local agricultural economies" in contact with extractive industries in the Chadian context.

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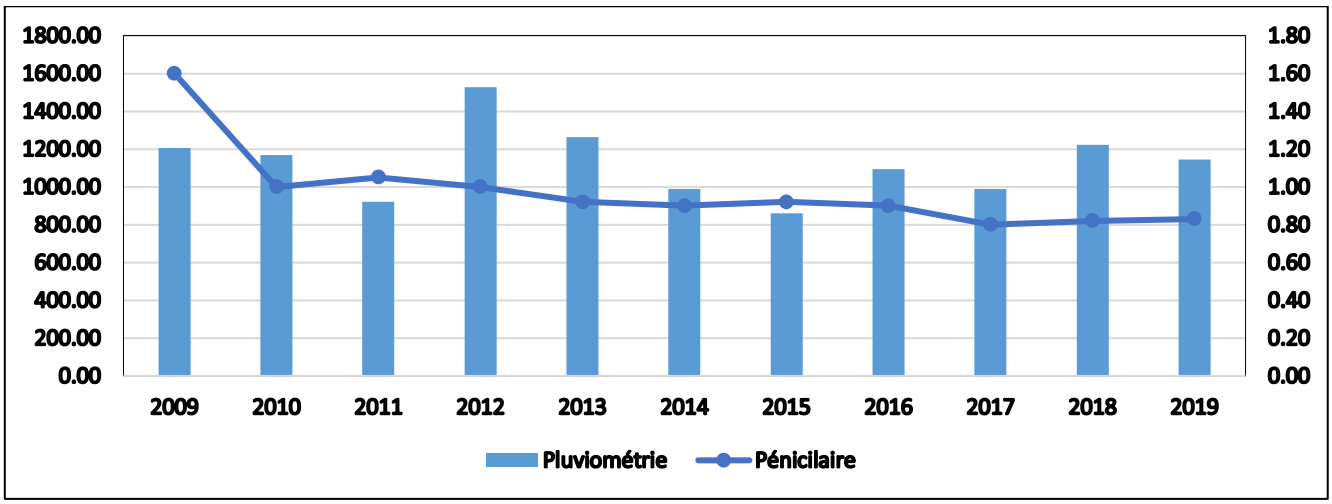

Figure 3 Variation from 2009 to 2029 in Pearl Millet Yields and Annual Rainfall
Analysis Results from Tchemsala Abbey, December 2020

Pearl millet (Pennisetum glaucum), commonly known as sea millet in the Sudanian zone, is the staple cereal crop for rural households in the Bongor basin. It serves both as a primary food source for household food security and as a commodity traded in local markets. With an average yield of 0.976 t/ha and values ranging from 0.80 to 1.60 t/ha over the period, pearl millet exhibits moderate but significant interannual variability (Table 2).

The graphical analysis of Figure 6 shows a general downward trend in pearl millet yields from 2009 to 2019, punctuated by slight increases. The sharp decline recorded in 2017 represents the lowest point in the series, followed by a slight recovery in 2018 and 2019. This downward trend is explained by several combined factors: the reduction in arable land for pearl millet due to the expansion of oil fields, soil degradation in areas near wells, particularly from irrigation water contamination and the upward movement of pollutants through the soil, and the scarcity of agricultural labor due to a shift towards oil-related activities.

From an agro-economic perspective, the decline in pearl millet yields has direct implications for the food security of rural households. In a context where pearl millet is the main staple cereal, a downward trend in yields equates to a progressive deterioration of the food security of family farms. This situation aligns with Abbaye's (2020) findings on the increasing proportion of households forced to purchase their food, and illustrates the process of food insecurity described by Lieugomg & Sama (2007) in oil-producing areas of Chad. Unless mitigated by agricultural support measures, the variability of yields will permanently undermine farmers' forecasting capacity and productive investments.

➢ *Variation in Sesame Yields*

Sesame (Sesamum indicum) is a cash crop with strong economic potential, whose seeds are exported to national and sub-regional markets. For many farming households in the Bongor basin, it constitutes one of the main sources of cash income, financing both schooling expenses and agricultural investments. With an average yield of 0.496 t/ha, it has the lowest average yield of all the crops analyzed and simultaneously exhibits one of the steepest declines over the study period.

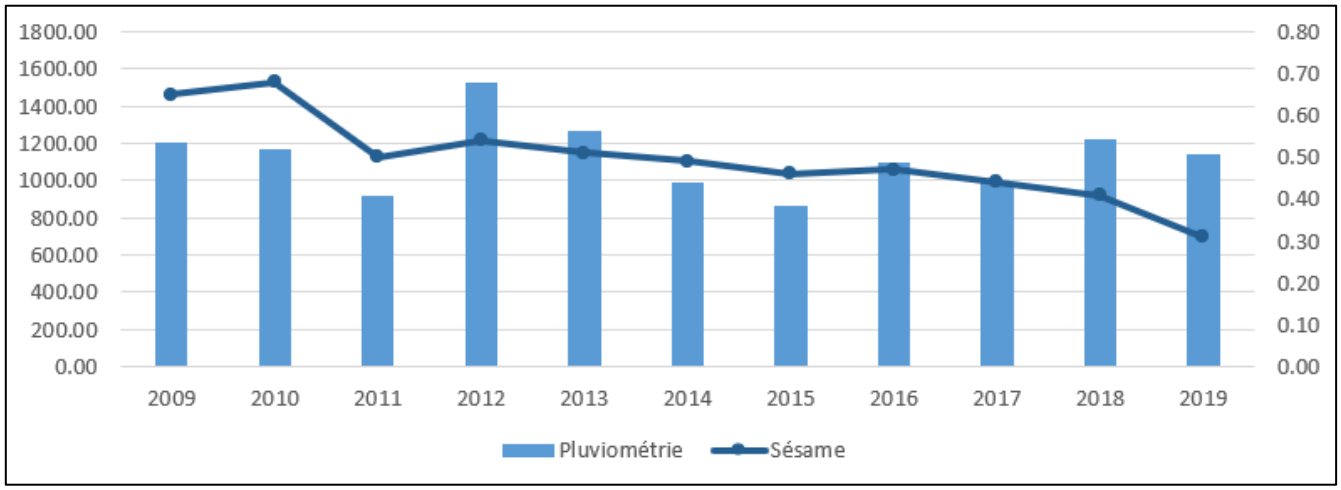

Figure 4 Variation in Sesame Yields and Annual Rainfall
Results of Analysis, Tchemsala Abbey, December 2010

ISSN No : -2456-2165 https://doi.org/10.38124/ijisrt/26may1032

Figure 4 illustrates a clearly downward trajectory in sesame yields from 2009 to 2019, falling from 0.7 t/ha to less than 0.3 t/ha, representing a yield loss of approximately 57%. The sharp decline recorded in 2011, the very year oil production officially began, is particularly significant, as it marks a clear break in the previous production dynamic. The slight recovery in 2012 should not obscure the underlying trend: yields subsequently remained at levels significantly below the historical average before continuing their decline until 2019. This dynamic reflects a dual impact of oil production: a direct impact, through the reduction of sesame-cultivated areas due to land expropriations; and an indirect impact, through soil and water contamination, which degrades the soil conditions necessary for sesame production, a crop particularly sensitive to soil quality. Contamination from industrial activities, such as hydrocarbon spills and leaks from wells and pipelines, alters the structure and chemical composition of surrounding agricultural soils (Magrin, 2001). For sesame producers, this degradation translates into a reduction in disposable cash income, directly affecting their ability to invest in their production equipment and cope with economic risks.

➢ *Variation in Sorghum Yields*

Sorghum (Sorghum bicolor) plays a central role in the agricultural systems of the Bongor basin. A crop with dual food and cash purposes, it represents both the main food security cereal for rural households and a commodity sold in local and sub-regional markets. With an average yield of 1.204 t/ha and a coefficient of variation of 24.5%, sorghum exhibits the second highest interannual variability in the series, after cotton.

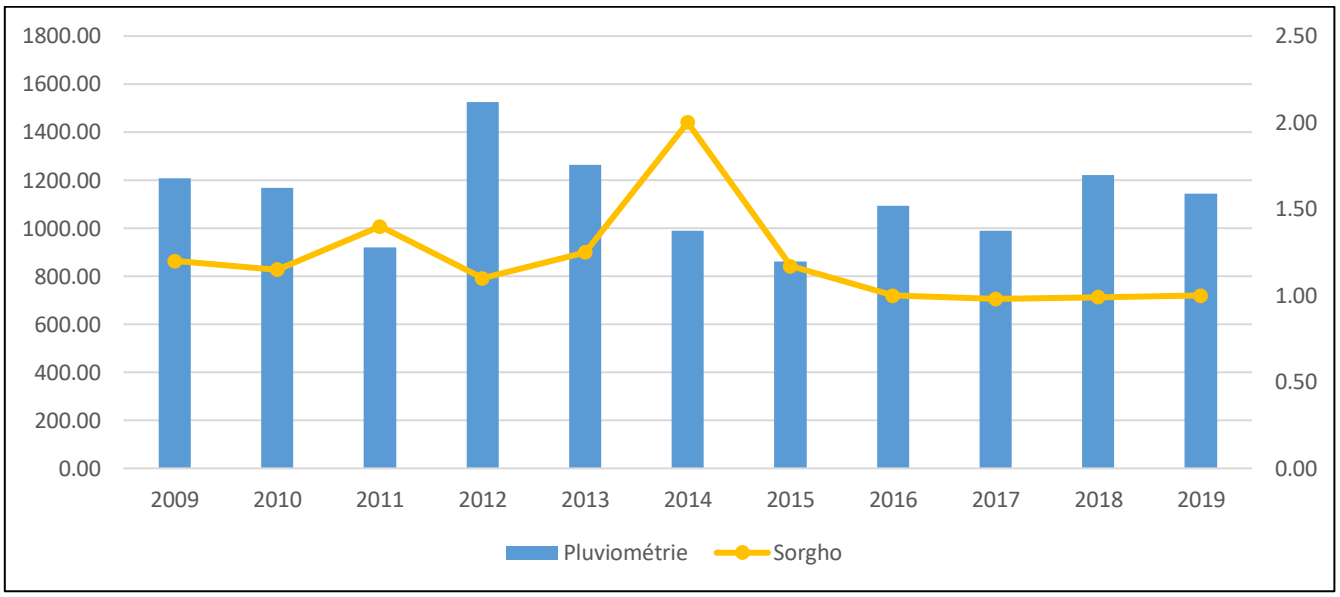

Fig 5 Variation in Sorghum Yields and Annual Rainfall
Results of the Tchemsala Abbey Analysis, December 2020

Figure 5 reveals a yield dynamic characterized by significant fluctuations. The exceptional increase in 2014, bringing yields to 2.00 t/ha (the highest in the entire series), likely corresponds to a particularly favorable harvest year, combined with relatively stable land and social conditions. This value represents an atypical peak: yields fell back to 1.2 t/ha in 2015, highlighting that the exceptionally favorable conditions of 2014 did not persist. Furthermore, a slight increase was observed in 2011 before the intensification of the effects of oil spills, followed by a small decrease in 2017, consistent with the general downward trend associated with other crops.

The instability of sorghum yields, combined with a general non-increasing trend over the period 2009-2019, reflects the progressive weakening of this crop under the combined effects of climate disruptions and the impacts of oil exploitation. In an extensive farming system where sorghum occupies a predominant portion of cultivated land, this instability weighs heavily on food security and agricultural incomes in the basin. It illustrates what Thune (2011) refers to as the "disruption of cereal balances" in rural areas affected by oil extraction, where the regulatory and planning capacity of farmers is severely undermined by land and production uncertainty.

➢ *Variation in Peanut Yields*

The peanut (Arachis hypogaea) is a dual-purpose legume: a food crop (oil, raw or roasted seeds) and a cash crop. Its biological fixation of atmospheric nitrogen gives it an agronomic role in improving soil fertility, making it an important component of crop rotation systems in the Bongor basin. With an average yield of 0.888 t/ha and a coefficient of variation of 10.5%, the peanut exhibits the greatest yield stability in the series, resulting from its relative drought tolerance and short growing cycle.

ISSN No : -2456-2165 https://doi.org/10.38124/ijisrt/26may1032

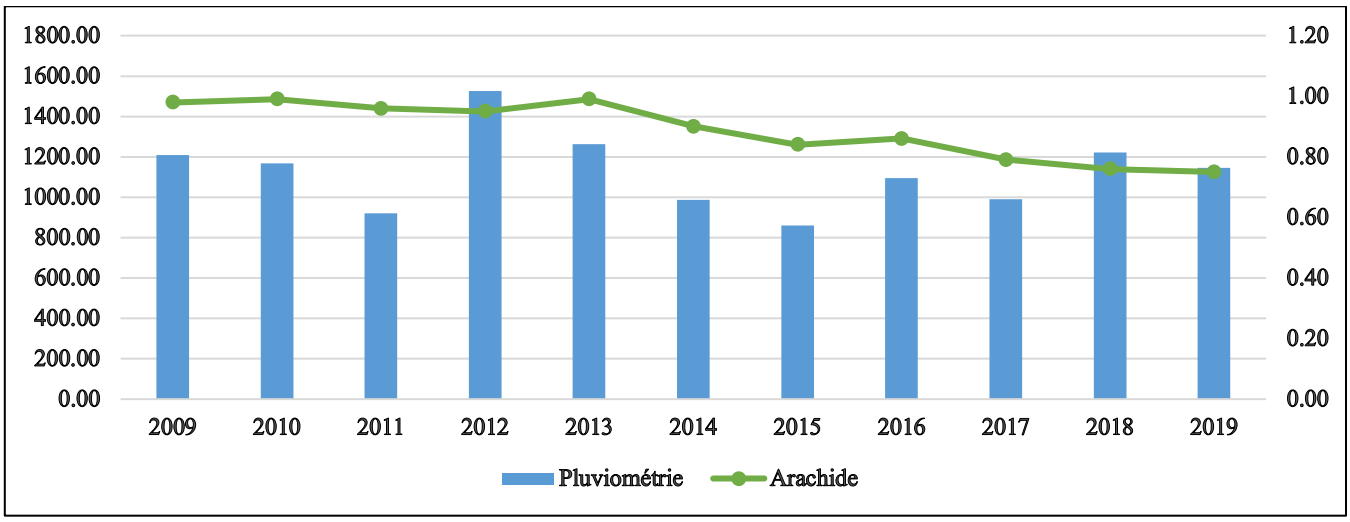

Fig 6 Variation in Peanut Yield and Annual Rainfall
Analysis Results, Tchemsala Abbey, December 2020

Figure 6 highlights a progressive downward trend in peanut yields from 2009 to 2019, falling from approximately 1.0 to 0.7 t/ha, representing a net loss of around 30% over the period. Yields remained relatively stable until 2014, followed by sharp declines until 2019, suggesting a delayed and cumulative effect of oil-related disruptions on this crop. The post-2014 decline coincides with the intensification of the effects of oil exploitation on agricultural land, particularly the acceleration of expropriations and the expansion of moratorium zones.

From a territorial perspective, the decline in peanut yields particularly affects production areas surrounding the Yamba Berté forest, an agricultural area historically dedicated to this crop. Land acquisition in this area by oil companies deprives peanut farmers of their best plots, forcing some to migrate to less fertile land or abandon peanut cultivation altogether. This dynamic aligns with Magrin's (2001) observations on the effects of spatial disruption on farming systems in Chad's oil basins. It also raises the question of the differentiated impact on women, who constitute the majority of peanut producers in the area and whose monetary income and economic autonomy are threatened by land dispossession linked to oil exploitation (Bennafla, 2000).

➢ *Cotton Yield Variation*

Cotton (Gossypium hirsutum) is the main cash crop in the Mayo-Kebbi area and plays a structuring role in the rural household economy, both in urban and rural areas. It constitutes the main source of cash income for many farmers and represents a major economic integration sector, supported by public cotton companies and local cooperatives. With an average yield of 1.019 t/ha and the highest coefficient of variation in the series (CV = 30.7%), cotton is the most unstable crop over the study period.

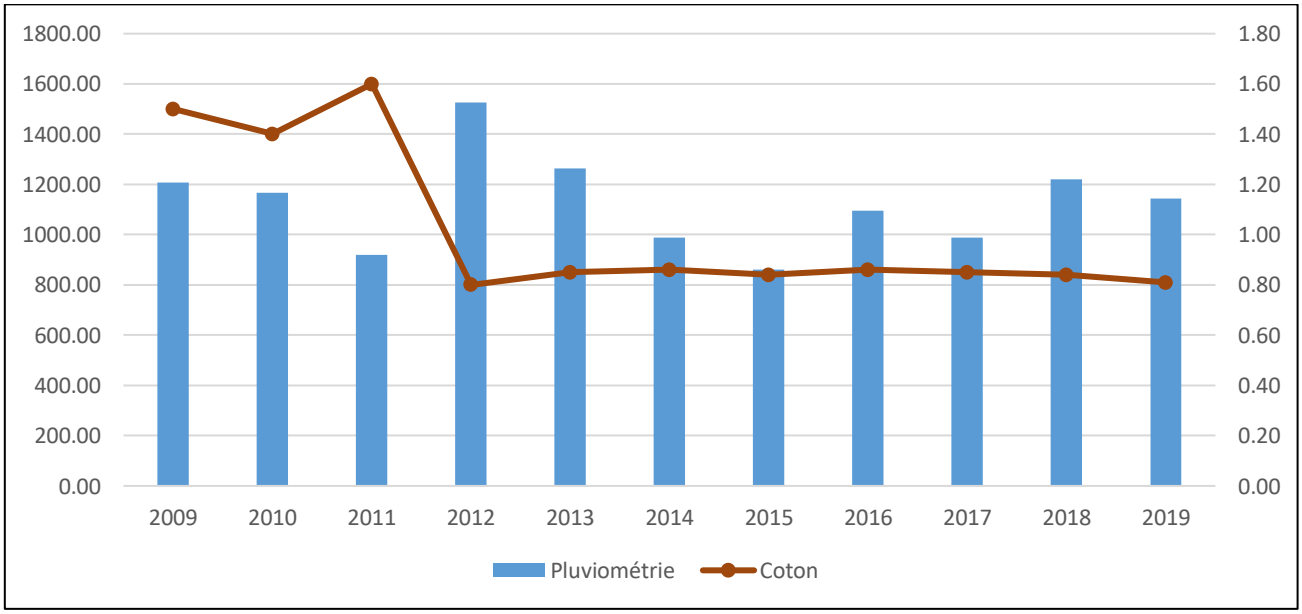

Fig 7 Variation in Cotton Yields and Annual Rainfall in Relation to Oil Production
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ISSN No : -2456-2165 https://doi.org/10.38124/ijisrt/26may1032

Figure 8 highlights two contrasting phases in the evolution of cotton yields. An initial phase of significant instability (2009-2012) is marked by a sharp drop in yields, falling from 1.1 t/ha in 2011 to 0.8 t/ha in 2012, representing a loss of nearly 27% in a single growing season. This sharp decline in 2011-2012 coincides precisely with the year of the official opening of the oil fields and the intensification of oil operations in the basin, confirming the close temporal relationship between the start of oil production and the decline in cotton production. A second phase, from 2013 to 2019, is characterized by a relative stabilization of yields at around 1.0 t/ha, but at a level below the historical pre-oil average.

This trend can be explained by several mechanisms. First, the reduction in available cotton-growing areas due to land expropriations forces farmers to produce on smaller plots, limiting the economies of scale inherent in cotton cultivation. Second, the disruption of the cotton sector by the indirect effects of oil exploitation—disruption of input supply chains and loss of specialized agricultural labor—degrades the technical conditions of production. Third, soil and water contamination from industrial activities affects the quality of cotton-growing land, the production of which requires well-structured soils and high-quality irrigation water.

The relative stabilization observed from 2013 onwards, despite a decline in yields, can be interpreted as the result of an adjustment by the remaining producers, who concentrated their efforts on the best available land, partially compensating for the loss of acreage through a slight intensification of farming practices. This partial resilience demonstrates the adaptability of the basin's farmers to shocks, but it cannot obscure the extent of the disruption to the cotton sector caused by oil exploitation (Magrin, 2001; Lieugomg & Sama, 2007). In the long term, if the current conditions of coexistence between oil and agriculture are not addressed by land protection and agricultural compensation policies, the cotton sector in the Bongor basin risks irreversible decline, depriving the area of one of its main sources of income and economic integration.

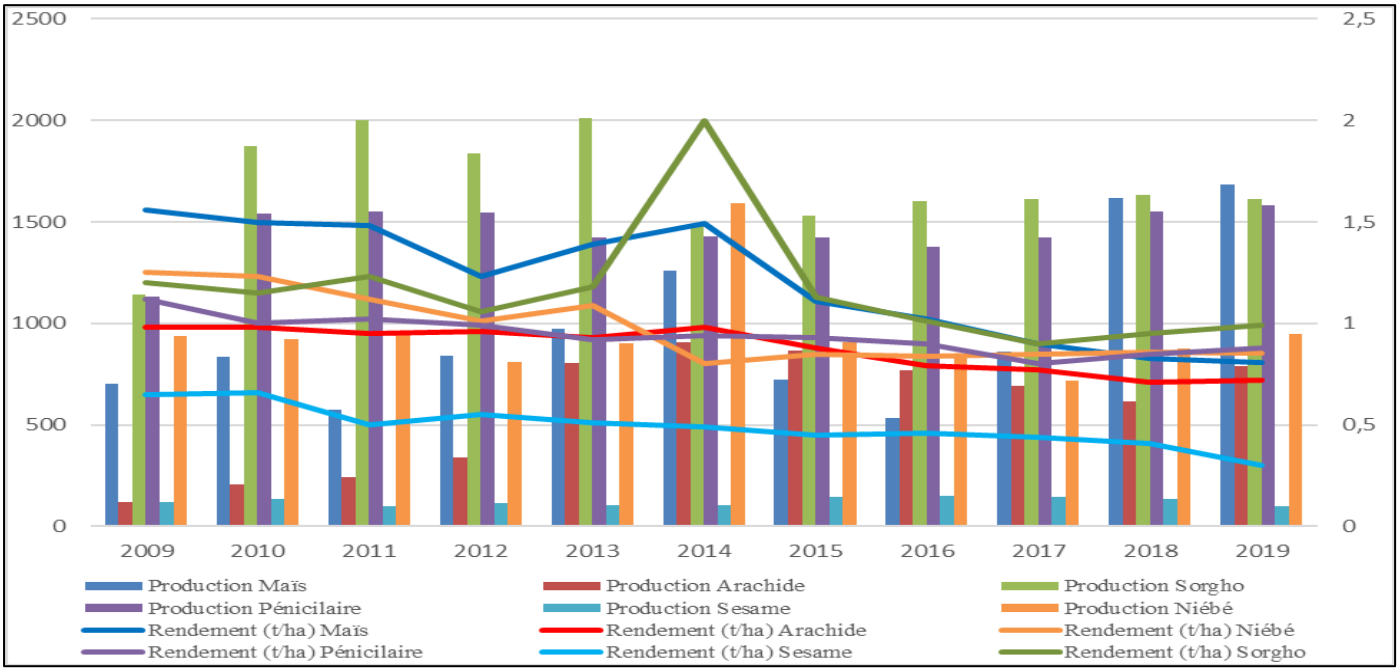

Figure 8. Contrasting Phases in the Evolution of Cotton Yields

Summary: The Combined Determinants of Agricultural Decline

The combined analysis of changes in food production (Figure 4), descriptive statistics (Table 2), Pearson correlations (Table 3), and variations in crop yields (Figures 5 to 8) provides an integrated understanding of agricultural decline in the Bongor basin.

Three main and interdependent mechanisms explain this decline. The first, related to land ownership, is the direct loss of agricultural land due to expropriations for oil fields, which mechanically reduces cultivated areas and, consequently, production volumes in an extensive farming system. The second, related to economics and demographics, is the retraining of agricultural labor for jobs in the oil and related sectors, which deprives local agriculture of its productive forces and fuels inflation in agricultural labor costs. The third, of an environmental nature, is the degradation of soils and water resources by industrial activities, which reduces the fertility of the remaining land and compromises yields on plots not yet expropriated.

These results confirm the central hypothesis of this article: the expansion of oil activities is indeed a factor in the decline of agriculture in the Bongor Basin. They are consistent with research conducted in other oil basins in sub-Saharan Africa, which shows that the introduction of mineral resource extraction in areas with strong agricultural potential generates land, economic, and environmental tensions that weaken local agricultural systems (Lieugomg & Sama, 2007;

ISSN No : -2456-2165 https://doi.org/10.38124/ijisrt/26may1032

Koulro-Bézo, 2001; Magrin, 2001). These results directly challenge the responsibility of the Chadian state and oil operators regarding the implementation of compensation mechanisms and the protection of the land and agricultural rights of affected populations.

IV. DISCUSSION

The debate surrounding the coexistence of oil and agriculture is a current issue in developing countries, particularly those for which agriculture is a core activity. Seen as an opportunity to diversify resources, local oil exploitation in the Bongor basin is disrupting agriculture, a pillar of the Chadian economy. This disruption, through a domino effect, is causing socio-economic repercussions that diminish the potential benefits of oil extraction.

This study has shown that oil exploitation leads to the loss of arable land, the abandonment of agriculture by populations who turn to oil work, and environmental repercussions on agricultural land and populations. It corroborates the findings of Lieugomg Médard and Sama Ozias (2007) that "the oil project is one of the factors reducing the available land for agropastoral activities. Indeed, the construction of roads, pipelines, drilling, and housing for workers, as well as the migration of populations, have largely encroached on land that was already contested by various rural actors."

For these authors, possessing oil resources can prove to be a curse, as these resources have a negative impact on the economic performance of countries and, particularly, on the localities that host them. Thune's assertion (2011, p. 5) that "the land occupied by the oil site makes it impossible to carry out the activities that previously exploited the soil and subsoil, primarily agriculture," is also a reality in the Bongor Basin.

This situation, combined with the pursuit of rent-seeking, profoundly threatens economic development (Krueger, 1974, cited by Aknin A., 2009, p. 17). Insofar as agriculture, the pillar of the Chadian economy, is being undermined across the Bongor Basin, the perception of oil activity as a sector of the future capable of helping Chad escape poverty, as advocated by the World Bank, is also being called into question.

V. CONCLUSION

The issue of oil-agriculture coexistence is a primary concern for Chad, where agriculture is the cornerstone of the national economy. Oil exploitation in the Bongor geological basin, which began in 2011, has multiple and varied repercussions on agricultural activity. Analysis of the interactions between oil exploitation and agriculture in the Bongor basin reveals a profound transformation of rural areas. The introduction of oil activities has led to intense pressure on land, significantly reducing available agricultural land and prompting a reorganization of land use. Furthermore, the economic attractiveness of the oil sector has encouraged the migration of agricultural labor to jobs related to extraction, resulting in a depletion of productive forces in the agricultural sector. Added to this is the degradation of natural resources, particularly soil and water, which directly affects agricultural productivity. These combined dynamics result in an overall decline in food production, thus jeopardizing the food security of local populations. Far from a harmonious coexistence, oil exploitation appears to be a factor in the detrimental restructuring of the agricultural system in the Bongor Basin. This situation highlights the need for improved territorial planning and an integrated resource management policy to ensure a sustainable balance between oil exploitation and agriculture. The state of agriculture in the Bongor Basin raises broader questions about the future of agriculture in all Chadian localities hosting extractive activities, a topic that should be explored in future comparative studies.

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