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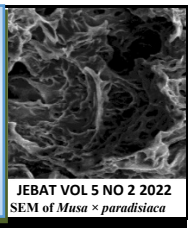

Implications of Artisanal Crude Oil Refining on Sustainable Food Production in the Niger Delta Region of Nigeria

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ABSTRACT

The rate of environmental degradation is an increasing trend globally and most especially in many developing nations where it has food production implications. This deterioration in environmental quality is mostly attributed to population growth, urbanization, industrialization, and unsustainable agricultural practices. The Niger Delta region of Nigeria is the oil and gas province of Nigeria. The activities of illegal crude oil refiners, theft, vandalism, etc. are common within the region, thereby leading to the degradation of major biophysical environmental matrices and conditions. Plant and fish-based diets are the major food sources for humans within the Niger Delta region. This review focuses on the implications of artisanal crude oil refining (ACOR) on sustainable food production in the Niger Delta region of Nigeria. The review found that the activities of artisanal crude oil refiners are harming the vegetation cover, altering the physicochemical and microbial composition of the soil, and releasing hydrocarbons into the environment, which are absorbed by vegetation leading to an increase in human and biodiversity contamination from ACOR as well as loss of arable farmlands, uncontrolled bush burning, and increased cases of soil erosion. Therefore, ACOR activities are having negative effects on food security, which is characterized by food availability, accessibility, stability, and utilization. Hence, there is a need to curtail the activities of ACOR through the issuance of operational liens followed by stricter regulations and monitoring of harmful emissions released during the processes.

INTRODUCTION

A majority of Nigeria's Niger Delta region is made up of a broad, low-lying sedimentary basin that is around 70,000 square kilometers in size and is drained by the Niger River. This basin is quite flat and has a relatively low elevation. The Niger Delta is home to a wide variety of ecosystems, including mangroves, lowland rainforests, freshwater forests, and aquatic ecosystems. These ecosystems contribute to the well-being of the local communities in the area. The area is home to a wide variety of plant and animal taxa, each of which makes a functional contribution to the region's ecology and economy. Insects, for example, are essential to the process of pollination; animal wildlife provides a source of protein, hides, and skins; plant genetic resources, such as timber, are used in construction projects; and shrubs and herbs, in particular, are utilized for the treatment of a variety of illnesses [1–5]. Other services rendered by the ecosystem include spawning grounds for diverse fishery resources as well as breeding and nesting grounds for migratory birds, shoreline protection, and habitats for wildlife [5–9]. These are all under severe threat due to human activities. The aquatic ecosystem of the area includes the sea, rivers, streams, creeks, etc. [10–14]. So much biodiversity is found in the Niger Delta aquatic ecosystem, including fisheries (both fins and shells), aquatic mammals, reptiles, insects, plankton, etc. [15–17]. Some species of each of these animal classes are found in marine, brackish, and freshwater habitats. For instance, whales and dolphins are mainly found in the marine water systems in the

Niger Delta. However, due to urbanization and industrialization, they are under severe threat. As a result, many of the species have not been found in the region for a very long time. The soil environment encourages the growth of several types of vegetation. The major types of soil in the region are distinguished from one another primarily by their proportions of clay, silt, and sand. The soil is one of the most important direct beneficiaries of human activities such as the processing of food. Some of the food crops that are cultivated in the Niger Delta include cassava, oil palm, maize, yam, etc. Furthermore, the Niger Delta is changing in terms of urbanization (land for residential, commercial, and industrial purposes), farmland (including agricultural pasture and bare fields within farmland), water (including stable and permanent surface water such as lakes, reservoirs, streams, estuaries, and ocean), and mangrove (land for flora and fauna) [1,18]. Other common activities in the Niger Delta region include artisanal crude oil refining (ACOR). The activities of ACOR involve the use of rudimentary equipment. Land use does have a big effect on food production because of the type of anthropogenic activities in the area.

Foods are a crucial component in any effort to achieve sustainable development and have a pivotal position in every society [19–25]. A sustainable food system ensures that everyone has access to sufficient food and adequate nutrition without risking the economic, social, or environmental underpinnings that will be necessary for food security and adequate nutrition for future generations. The current global food supply chain is in danger of being disrupted as a result of rapid urbanization, industrialization, and other human activities [26]. This is already affecting food production, trading, processing, and consumption. The global food trade and business models that are nutrition-insensitive have fostered and maintained unhealthy eating patterns, leading to a shift in dietary norms. Presently, the cost of nutritious foods has soared. Significant social and environmental effects are impeding progress toward the Sustainable Development Goals of 2030. The practices we employ in food production and consumption are having a profound impact on the environment and societies of the world [26].

Food sources for humans are obtained from terrestrial as well as aquatic ecosystems. These foods are mainly from plants [27 – 38], animals [39 – 41], and microbes or involving microorganisms to a lesser extent. Due to human activities, these environments (terrestrial and aquatic) are under intense stress, leading to the loss of biological resources [8, 42, 43], and habitat modifications. The focus of this review is to outline the implications of ACOR on sustainable food production and supply. The findings of this review will be useful to individuals, societies, and agencies interested in sustainable food production as a means of avoiding potential food crises. The review concludes by suggesting means of overcoming the hurdles.

Crude oil-related activities in the niger delta region of nigeria

Throughout the previous half-century, Nigeria has placed a significant amount of importance on the exploration and eventual marketing of crude oil. These pursuits are responsible for a significant source of the country's foreign earnings [15, 44]. It is estimated that Nigeria produces over 2.5 million barrels of crude oil every single day, making it the largest producer of oil on the continent of Africa and the sixth largest producer in the entire globe. It is interesting to note that only 7.5% of the total land area is responsible for the production of this high price and volume of crude oil (The Niger Delta region) [45]. In Nigeria, only states that produce crude oil can be considered to be fully capitalizing on their crude oil potential and are found in the Niger Delta area. Of these states, Akwa Ibom, Delta, Rivers, and Bayelsa are responsible for producing 80% of the total crude oil produced in Nigeria [46, 47]. Authors have reported that the region of Nigeria known as the Niger Delta is one of the most environmentally impacted regions in the world due to crude oil as a result of poor regulations coupled with the activities of artisanal crude oil refiners [48; 49]. The activities of natural gas and crude oil production in the region are the major reason why it is often referred to as one of the most polluted regions in the world. In the Niger Delta region of Nigeria, the activities of oil and gas in onshore and offshore ecosystems have led to the loss of life forms and habitat destruction. According to Sam and Zabbey [50], over 13 million tons of crude oil have spilled into the environment of the Niger Delta, contaminating the soil and aquatic ecosystems. Aigberua et al. [51–53] have reported that crude oil alters soil physiochemical characteristics.

In addition, illegitimate oil bunkering exists in the region. Theft is responsible for the loss of an estimated number of oil barrels each day that ranges between 200,000 and 300,000 (Obenade and Amangabara, 2014). The vast majority of the stolen crude oil is transferred to enormous tankers capable of crossing oceans that are waiting offshore. These tankers then export the oil to refineries located outside of the country. The remainder of the stolen oil is processed through artisanal refining, which refers to the transformation of stolen crude into low-quality petroleum products [54].

According to Okumagba [49], about $4.5 billion was lost in Nigeria in the year 2020 due to the activities of petroleum pipeline vandalism and crude oil theft. However, it is vitally important to keep in mind that the damage to the environment that is produced by the ACOR is significantly more severe than the damage that is generated by the legitimate exploration of oil reserves. In addition, the environmental catastrophe is to blame for the people losing their sources of income in the first place. Onuh et al. [55] opine that although big oil companies are polluting the environment in the Niger Delta, they are not entirely responsible. This is because unregulated artisanal refineries have made the situation much worse by using old and inefficient technology. This technology is similar to that which is used by the locals for the distillation of ethanol.

Illicit refineries are now a key component of the local economies in many villages in the Niger Delta. As a result, refined products are making their way to other regions of the country through licit distribution networks. As a direct result of the rapid growth of illegal oil processing camps across the Niger Delta, a semi-structured, informal, and highly entrepreneurial economy has emerged. This expansion has been most noticeable in the Delta, Rivers, and Bayelsa states. The fact that every local area is responsible for managing its value chain is one of the defining characteristics of this type of economy. Even though ACOR has been the subject of a large number of studies that have taken a diverse range of approaches, there has been a consistent finding throughout these studies and among the researchers that it is harmful to the environment.

Obenade and Amangbara [54] demonstrated that, despite the apparent social and economic benefits that artisanal refining brings to the host communities and the argument that the practice responds to the issue of unemployment and poverty, particularly in the country's oil-producing areas, the infractions far outweigh the supposed benefits to the community as well as the overall environment. This is because the infractions include the release of pollutants into the air, water, and soil, as well as the use of

hazardous materials. This is because the violations include putting pollutants into the air, water, and soil, which all have the potential to hurt people. The most significant issue is that illegal refiners disregard all of the environmental protection principles that are known to be involved in the process of refining crude oil. These illegal refiners empty the residue that is left over after boiling the crude into nearby soil, rivers, creeks, and other bodies of water. This is the key factor contributing to the environmental degradation caused by the activities of ACOR in the Niger Delta. The fact that there have been a substantial number of fires in the region near artisanal refining operations is an indication of how dangerous the process can be. The ecological disasters caused by ACOR include the loss of wildlife and their habitats, the loss of medicinal plants, and the disruption of the water cycle. ACOR also affects the beauty of the forest and the growth of plant species [56].

According to several reports, the processing of crude oil and heating both contribute to air pollution, which is harmful to human health and poses a risk to individuals. The working conditions in the camps are dangerous, and it is not clear what effect this will have on the health of the people who do the labor there over the long term. The inhalation of toxic gases is a persistent risk to communities, and it can cause respiratory disorders and difficulties. Some other consequences of this are that it causes acid rain, which not only prevents plants from growing properly but also kills marine and terrestrial animals. It has been known for a long time that it poses a serious risk to the way of life of the people who live in oil-producing regions, the majority of whom make their living as fishermen, farmers, and craftsmen. The fact that it poses this risk has been recognized for a long time [55]. The fact that ACOR is still in operation, despite the damage they inflict on the environment and the hazards they pose to people's health, is because it is very profitable.

The activities of ACOR in Nigeria's Niger Delta have contributed to an increase in the level of toxicity of the soil [48, 57]. This finding was based on their findings that the refinery of crude oil in the Niger Delta takes place locally. This has changed the chemical makeup of the soil, which, if left unchecked, could have disastrous effects on the ecosystems of the region [48].

Overview of food security

The Food and Agriculture Organization (FAO) provides the following definition of what it means to have food security: “when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that fits their dietary needs and food preferences for an active and healthy life”. Therefore, food security implies that all people, at all times, have access—both physically and economically—to adequate quantities of foods that are nutritious, safe, and culturally appropriate; that these foods are produced in a manner that is both environmentally sustainable and socially just; and that people can make informed decisions about the foods that they consume. Food security also refers to the fact that the individuals who raise, catch, produce, prepare, transport, and retail our food can earn an adequate salary that allows them to support themselves and their families while doing so. Food security is composed of four interdependent aspects: availability, access, use or utilization, and stability. Availability, access, use or utilization, and stability are interconnected (**Fig. 1**).

The term "availability of food" refers to the supply and trade of food, which encompasses not only the quantity of food but also its quality and the range of available foods. Food availability can become an issue when there is a lack of critical resources, such as water for irrigation, or when land that is being used for food production is destroyed or degraded. Both of these scenarios can make it difficult to produce enough food to meet demand. To raise the available amount, we need agricultural practices that are both sustainable and productive, as well as naturally occurring resources that are well-managed, and regulations that boost productivity. As a result, food availability refers to the efficiency with which food is produced, which can be done through domestic food production, as well as commercial food imports and exports.

Individuals need to have access to the resources that will enable them to acquire food of an acceptable quantity and quality before there can be genuine food security. Both economic and physical access is required to consume food. Smallholder farmers need to have greater access to markets for there to be an improvement in access. This will provide them the opportunity to raise the amount of money they generate from cash crops, products from livestock, and other industries. The availability of food is affected by a wide range of factors, such as those that are physical, social, and policy-related, as well as factors such as pricing, geographical location of households concerning food sources, and infrastructure. The availability of food is also impacted by infrastructure.

Food usage and use are terms that relate to the process by which the body makes use of the numerous nutrients that are included in the food. These nutrients can be found in a variety of foods. To have food security, it is necessary that the food that can be accessed be of high quality. It is of the utmost significance that individuals have access to food that is nutrient-dense and healthy enough to offer them the energy that they require for the activities that they engage in daily. Additionally, it is of the utmost need for individuals to be equipped with the information and resources essential to effectively "utilize" the food that is made accessible to them. The nutrition status of an individual is susceptible to being influenced by a wide range of factors, such as their state of health, how they consume food, the breadth of the diet that they follow, and how food is allocated within their household. It is vital to improve nutrition and food safety, increase the diversity of foods consumed, reduce post-harvest loss, and add value to food to increase usage. These are the steps that need to be taken. One way of thinking about stability is as a temporal dimension that exerts an effect on every level. To maintain one's stability, it is necessary to always be in a position to provide for one's food supply.

A good level of food stability indicates that access to food, its availability, and usage have remained generally unchanged over time. It is vital to aim toward eradicating or lowering the potential risks associated with this stability to the greatest extent possible. Natural disasters, a changing climate, armed conflict, and economic variables such as volatile price changes are some of the factors that represent a threat to the stability of the food supply. These are some of the factors that offer a threat. It is impossible to have total food security without all four components being in place.

The significance of sustainability, which may be considered the fifth component of food security because it pertains to the passage of time over the long term, has come to the forefront as a result of more recent occurrences. The most productive way to think about food security is as a chain of causes and effects stretching from production to consumption, distribution to processing. This line of thinking is supported by a variety of academic fields and is widely considered to be the most accurate representation of the phenomenon. Because a considerably larger

proportion of their income is spent on food by them, the poor are at the greatest risk whenever there is an increase in prices. This is because prices have increased.

Implications of artisanal crude oil refining on sustainable food production and supply

Communities in the Niger Delta that do not have access to potable drinking water are extremely reliant on water from rivers in Nigeria as their primary supply of drinking water. This is because rivers are the only other source of water in the region. In addition to the waste and discharges associated with anthropogenic operations, the activities related to the exploration and production of crude oil have contributed to the contamination of soil, the degradation of ecosystems, and the pollution of ground and surface water systems.

Not only does the contamination of aquatic ecosystems with crude oil and other petroleum products make the water unfit for human consumption, but it also prevents the native flora and fauna from performing their fundamental tasks. This is because humans are the source of the contamination. In addition to this, the actions of ACOR have led to the destruction of fish habitats and breeding grounds in the mangroves of the Niger Delta, and they have produced considerable levels of contamination in the marshes and rivers in the region [48]. The activities of ACOR in the Niger Delta are affecting food production and supply as a result of the following: the loss of vegetation cover that serves as food to humans; the alteration of physicochemical and microbial characteristics of the soil and water; the release of hydrocarbons into the environment that can be up taken by vegetation; the increased ambient and soil temperature; the contamination of soil by toxicants that could be up taken by plants; the loss of arable land as a result of ACOR activities; the loss (**Table 1**).

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The activities of ACOR have been polluting the soil with hydrocarbon components [48], which has led to a decline in the quality of the soil as well as increased leaching and erosion. As a result, agricultural production has decreased. The biological, chemical, and physical aspects of soil are the foundational components of its quality. These properties are influenced by the topography, climate, and, most crucially, humans. The long-term viability of an agricultural production system in a given soil type is determined, in large part, by the actions and choices made by humans. The capacity of soil to take in, reuse, and store water, energy, and minerals for the sake of crop production is one way to characterize the soil's quality. The contamination of soil by hydrocarbons from crude oil has a very significant effect on the reduction of some of the mineral components that are present in the soil [48]. Therefore, the alteration of the biological, chemical, and physical soil conditions will affect the ecological role of the soil and lead to a decrease in the ability of the soil to allow plant species to grow. Oil spills and crude oil activities, including ACOR, have several negative effects on the environment and have become increasingly frequent as a result of an increase in the extraction, refining, transportation, and trade of petroleum, especially in the Niger Delta region of Nigeria. The contamination of soil with oil improves the availability of water and nutrients and also compacts the soil, which has a direct impact on the growth and productivity of plants [58]. Oil contamination has the following major effects on plants: changes in morphology, physiology, and anatomy [58].

As a result of the pollution caused by crude oil, the soil's physical features, such as pore spaces, may get blocked. This results in decreased soil aeration decreased water infiltration and increased bulk density of the soil, all of which may have an impact on plant growth [59]. The outcomes of both the physical and chemical tests carried out on the crude oil-contaminated soil showed a variation in petroleum hydrocarbons, organic carbon content, C/N ratio, and soluble salt content [60, 61]. The studies showed extreme levels of these parameters are evidence of their effect on plant growth [60]. Ogboghodo et al. [62]; Osawaru et al. [63, 64] reported that crude oil affects the chemical characteristics of the soil leading to an increase in organic matter, and a decrease in available P. The authors further reported that the high levels of pollution caused by crude oil impeded the growth of maize.

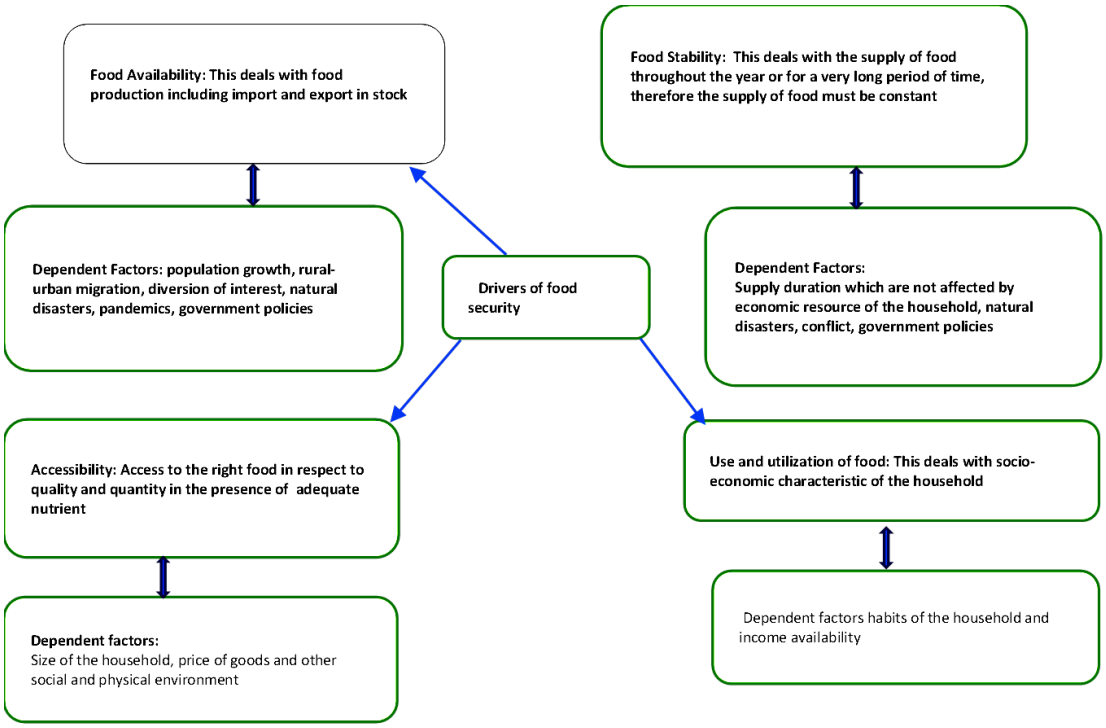

Fig. 1. Drivers of food insecurity.

Table 1. Implications of ACOR on sustainable food production and supply in the Niger Delta.

Effects	Sustainable food production	Implication
Vegetation cover	Since conventional methods of heating are utilized, the temperature in the area surrounding ACOR is typically quite high. It causes the destruction of vegetation as well as other species of life forms that provide a source of sustenance for humans.	Food availability will be low or inadequate.
Alteration of physicochemical characteristics of the soil	The environment of ACOR is typically contaminated; therefore, changes are made to the physiochemical features of the soil, which affect the structure, texture, and other physical and chemical properties of the soil, as well as the nutrients that can be used by plants. Due to this, the soil contaminated by the activities of ACOR is detrimental to agricultural activities.	The availability of some food around the ACOR site will be low or inadequate.
Alteration of the microbial composition of the soil	Microorganisms are present everywhere and may survive in a wide variety of environments. Microbes are not only necessary for the breakdown of waste but also for the development of certain of the human diet's sources of food. As a result, the activities of ACOR may change the microbial composition of the soil, which may in turn affect the roles that soil microorganisms play, such as the production of particular kinds of food.	The availability of some food around the ACOR site will be low or inadequate.
Release of hydrocarbons into the environment which can be absorbed by vegetation	The majority of the components that make up crude oil are hydrocarbons. These crude oil spills typically occur in the ACOR environment, resulting in pollution and the release of hydrocarbons into the surrounding environment. There is a possibility that the plants will perish entirely if there is a sufficient number of hydrocarbons in the environment. In addition to this, it has the potential to make the soil challenging for plants to develop in.	The availability of some food around the ACOR site will be low or inadequate. The human that consumes the food crops cultivated in ACOR sites could be adversely affected health-wise.
Increased temperature	The temperature of the ACOR sites is usually high. It can outrightly kill some vegetation that surrounds them. Some of the vegetation covers are food sources for humans.	Food availability will be low or inadequate.
The possible spill of crude oil leading to bioaccumulation by plants	Plants have the inherent capacity to accumulate harmful substances from their surroundings through a process known as bioaccumulation. Therefore, the limited flora that can flourish in the crude oil-contaminated location may be capable of bioaccumulating the hydrocarbons and other chemical toxicants linked to crude oil. People may get sick if they eat these plants because they have taken in toxic chemicals from crude oil.	The availability of some food around the ACOR site will be low or inadequate. A human that consumes the food crops cultivated in ACOR sites could be adversely affected health-wise.
Loss of arable land due to ACOR activities	Because the ACOR sites are often contaminated by crude oil. This makes it difficult for much vegetation to grow on the site. This reduces the amount of arable land available to farmers for agricultural activities.	Food availability will be low or inadequate.
Bush burning	Because the refining of the crude oil is done using conventional heat in the bush, i.e., outside the residential areas, sometimes the fire escalates into the bush and goes on uncontrolled. In the process, the food source of man will be destroyed, including farm plantations and their produce, wildlife, and other essential roles in ecological balancing.	Food availability will be low or inadequate.
Leaching and erosion	When the vegetation in the ACOR sites are removed. It exposes the environment to soil erosion. Intense soil erosion creates permanent scares in the areas which could expand if not controlled and could lead to loss of arable farmlands	Food availability will be low or inadequate.

Tanee and Albert [61] conducted a reconnaissance assessment of the long-term effects of crude oil spills on soil chemical properties and plant composition and provide evidence of the crude oil spill's long-term impact on terrestrial ecology. The authors further reported that *Aspillia bussei* and *Heterotis rotundifolia* were noticeably prominent in the polluted environment, whilst *Chromolaena odorata* and *Panicum maximum* were completely eradicated, demonstrating the plants' relative susceptibilities and resistances to high levels of total hydrocarbon content and suggest that crude oil could also impact on food crops used by humans.

One of the most hazardous components of crude oil is called polycyclic aromatic hydrocarbons, often known as PAHs. Because of this, having a good grasp of the dangers associated with PAHs and how they are related to soil biological factors is essential. Wang et al. [65] reported that crude oil statistically enhances the concentration of total petroleum hydrocarbons, total organic carbon, pH, carbon/nitrogen, and carbon/phosphorous ratios and lowers total nitrogen. The authors further reported that the time duration of production determines the level of effects on the chemical changes in the soil's chemical characteristics. Chakravarty et al. [66] reported that PAH could decrease the activities of soil dehydrogenase, urease, alkaline-phosphatase, catalase, amylase, and cellulase by 1.5 – 2.3 folds. Zhang et al. [67] and Chakravarty et al. [66] reported that polycyclic aromatic hydrocarbons in contaminated soil are carcinogenic. In addition, PAHs have been linked to the development of chromosomal mutations, disruptions in the fusion and junction processes, and even the induction of chromosomal breaks [68].

As a direct result of this, the genetic material that is contained in these cells degenerates and becomes unstable [68]. These PAHs have been reported in the soil environment in the Niger Delta [69,70]. Besides oil and gas activities, PAHs can be released into the environment during the incomplete combustion of coal, wood, garbage, or other organic materials [70]. PAH has also been found in seafood from the Niger Delta, like prawns, periwinkle, crab, and oyster [71], as well as in vegetables like *Chyrysophyllum albidum, Telferia occidentalis, Vernonia amygdalina, Talinum triangulare,* and *Elaies guinnensis* [72, 73]. Furthermore, PAHs have been reported in food sources of men from other parts of Nigeria, including Lagos, in edible vegetables such as *Corchorus olitorius, Celosia argentea, Amaranthus cruentus, Telfairia occidentale, Basella alba, Lactuca sativa, Allium ascalonicum,* and *Talinum triangulare* [74]. In addition, PAHs have been detected in food crops in some other parts of the world [75, 76].

Udoh and Chukwu [77] reported that considerable soil contamination is always present when oil pollution is present, leading to nutrient deficiencies as well as remarkable rises in soil total petroleum hydrocarbons and the concentration of several heavy metals. The authors reported that the effects of the pollution will become less severe over time and that the agricultural productivity of the land, the pollution of groundwater, and the health of the population are all severely impacted as a result of this. Studies in the Niger Delta have documented the effects of hydrocarbon pollution on crop production. The effects of hydrocarbons have not only impacted the crops but also the sustainable livelihoods of several families in the area. Studies have shown that farmers in areas where hydrocarbons are a problem make less money. Inoni et al. [78] studied the detrimental effect that an oil spill has on crop output using crop farmers' random from 10 towns and 5 local government areas located in the oil-producing agro-ecological zones of Delta State, and reported that an oil spill causes a reduction in crop yield, land productivity, and a significant decrease in farm income. The authors concluded that for every 10 % rise in oil spilled, there was a 1.3 % reduction in crop output, and farm income fell by 5.0 %. This could be because volatile portions of petroleum hydrocarbons play a significant role in inhibiting germination and postponing the emergence of seedlings. Yabrade and Tanee [57] observed that the total hydrocarbon content in the studied sites had very high toxicity levels, which led to changes in the chemical characteristics of the soil.

Because of the toxic, mutagenic, and carcinogenic properties of crude oil, crude oil spills into the soil from neighboring crude oil refineries pose a significant threat to human health [79]. These spills also make it hard for healthy microorganisms to work together, which can be bad for human health. Since the activities of ACOR in the Niger Delta are carried out in the coastal and upland regions, it could affect the major source of animal proteins, fish. Instances of fish dying in coastal regions in large quantities have been reported in the region [80]. Again, in areas where ACOR is common, sheens of crude oil have been seen converging on the surface water i.e rivers. This oil sheen could interfere with the oxygen supply to aquatic organisms such as fish and eventually lead to a decline in the composition, diversity, and population of fish. Dark sludge, which is considered crude oil waste, is released into the environment, and it could result in the creation of a wasteland effect across huge areas. The waste could have an impact on the flora and fauna, as well as the groundwater system and the aquatic environment. The flares that are produced at the ACOR sites are a significant contributor to the region's overall levels of air pollution. According to Sam and Zabbey [50], oil pollution is a big worry for local communities since spilled oil contaminates life-supporting ecosystems and food chains.

CONCLUSION

The food system is at the center of any society as an indispensable component in the process of achieving long-term, sustainable development. A food system is considered to be sustainable when it can provide food security and adequate nutrition for all people without compromising the economic, social, or environmental foundations necessary for subsequent generations to achieve food and nutrient security. The increase in population, urbanization, and industrialization, as well as cultural norms that do not contribute to agricultural sustainability like ACOR, are the primary causes and drivers of deterioration in environmental quality and quantity. The oil and gas province of Nigeria is located in the region of Nigeria known as the Niger Delta. The regular occurrence in this region of illicit crude oil refiners, crude oil theft, vandalism, and other similar crimes contribute to a deterioration of the region's primary biophysical environmental conditions necessary for food production. The majority of the food that humans consume comes from plants and seafood and the systems necessary for these food sources are often compromised by ACOR activities. The effects of artisanal crude oil refining on the viability of food production in the Niger Delta region of Nigeria as presented in this review suggest they hurt vegetation cover, alter the physicochemical and microbial composition of the soil and water by releasing diverse hydrocarbons into these environment matrices that eventually accumulate and cause numerous negative effects. Some other effects of ACOR include loss of arable farmland, uncontrolled bush burning, and increased susceptibility of soil to erosion. These activities are hurting the food security in the region through a reduction in food availability, accessibility, stability,

and utilization. As a result, it is necessary to halt all and some ACOR activities through policies, issuance of operational licenses, stricter enforcements of regulations and monitoring of harmful emissions in the region.

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