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AN APPLICATION OF STOCHASTIC MODEL IN CRUDE OIL SPILLAGE AND ITS IMPACT ON ENVIRONMENTAL DEGRADATION

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Abstract
Crude oil was first discovered in the Niger Delta in large commercial quantities in 1956. Since then, oil drilling has continued, resulting in what is known as environmental degradation, as a result of the multinational companies' indifference and hostile attitude toward environmental management in the region. This study aims to scientifically evaluate the environmental impacts of crude oil spills by examining the harm they do to farmlands. Finding out how frequently oil has leaked into agricultural land in one of Delta State's oil-producing districts was the aim of the study. The frequency of crude oil spills and how they impacted crop productivity were evaluated on small-scale commercial farmers. The method of ratio estimation was employed to analyze the collected data. The result indicated that 20% of farmlands are currently damaged by oil spills, according to the study's estimates, demonstrating the considerable harm that oil spillage causes to farmland. An estimate of over N1.16m in economic loss occurs annually as a result of farmland contamination brought on by local crude oil spills.

Keywords: environmental statistics Crude oil spillage, agricultural production, environmental degradation, ratio estimation, Niger Delta

INTRODUCTION

The long-lasting impact that agricultural production has had on the economic development of Nigeria and other countries has received commendation from many individuals. Nigeria and most other emerging nations see agricultural development as crucial to overall economic development. One of the nine (9) states in Nigeria's Niger Delta, Delta State has an abundance of natural resources and a climate that supports year-round agricultural production. Farm holdings and small-scale farming operations are typical. Since farmers have limited access to modern

farming supplies like herbicides and fertilizers, mechanization is very constrained in its scope. Despite its laborious agricultural output levels, Delta State is one of Nigeria's leading producers of crude oil and is located in the Niger delta, the center of the nation's oil and gas industry. Despite the increased income from crude oil exploitation, the populations in the Niger Delta where this resource originates continue to live in social misery and acute poverty.

In addition, the rapid growth in agricultural output will benefit the poor in both urban and rural areas who spend a big percentage of their income on food by increasing land and labor productivity. Since a large percentage of people still rely primarily on agriculture and agricultural goods for their income, increasing productivity will result in higher incomes for both farmers and even non-farmers.

Odjuvwuederhie et al. (2016) assert that all phases of oil exploitation have a negative influence on the ecosystem, with oil leakage being the most significant and unsolvable issue brought on by crude oil exploration in the Niger Delta region. Prior to the discovery of oil, the residents of the Delta region made a living as farmers, fishermen, and hunters by using the land, water, and forest resources. Because they understood how important the environment was to their survival and the survival of future generations, they developed strong ties to it.

According to Nwosu (2011), agricultural pursuits and international trade have historically fueled economic expansion. The Nigerian government was able to fund investment projects before to independence thanks to the proceeds from the sale of agricultural goods. The high level of agricultural contribution to economic growth is implied by the fact that in the 1940s and 1950s, over 75% of Nigeria's yearly merchandise exports were composed of agricultural export items.

Oil companies have made enormous profit in the country. Vanguard Nigeria reported that Chevron Corporation has reported earnings of $3.7 billion for the fourth quarter of 2018 (Vanguard 5th February, 2019). These companies have contributed minimally to the country’s development. In the same vein, communities oil spills have posed a major threat to the environment which has led to total destruction of the ecosystem and thus life for both plants and animals in these areas have become increasingly unbearable due to the ugly effects of oil spills, notably in Erhoike, Kokori Ethiope East region of Delta State. Recurrent oil spillages have rendered vast stretch of indigenous farmlands useless. Oil spill has serious impact on the vegetation and wildlife to the extent that plants can no longer survive and those making a living from the sea resources have become economically abandoned. In the light of this, this study seeks to investigate the effect of oil spillage on agricultural production.

Al-mawali et al. (2016) developed a straightforward macroeconomic model to simulate the effects of the oil sector on the economy of the Sultanate of Oman. They found that the oil industry had a significant and favorable impact on Oman's GDP, as well as on all other economic sectors other than the oil industry. They concluded by saying that the Omani economy cannot be diversified and that the main impact of oil was on the gas sector.

In Rivers State, Nigeria, Ojimba (2015) conducted a comparison study of agricultural productivity in fields with and without crude oil pollution. According to his findings, the average size of a peasant farm in crop farms that weren't polluted by crude oil was 1.60 hectares, which was larger than the average size of a peasant farm in crop farms that were (1.45ha). This reduction in the area of farm size cultivated, reduced the total quantity of crop output and hence the farm income realized by farmers from crude oil polluted farms when compared to the non-polluted farms. This led to his conclusion that crude oil pollution had detrimental effects on crop production.

Ojimba (2017) looked into the relationship between farm size and pollution from crude oil and the level of poverty among farmers in Nigeria's Rivers State. His research's findings indicate that households in crop farms with crude oil pollution were more likely to be poor. He therefore came to the conclusion that crop farmers in the state were suffering due to crude oil pollution.

Oil spills have significant negative effects on human health, the environment, and agricultural productivity. According to Nnabuenyi (2011), who saw the detrimental impacts of oil spills on agriculture, the majority of farmlands have been devastated, rivers have been contaminated, killing fish, and most farmers and fishermen are now jobless. According to Chindah and Braide (2019), the high oil retention period in the soil brought on by restricted flow contributes to oil spills' significant harm to the oil communities. In the end, crops are killed because this prevents adequate soil aeration and negatively impacts soil temperature, structure, nutrient status, and pH.

According to a study by Unuado (2011) on the impact of oil spills on crop production in the Niger Delta, oil spills on crops inflict significant harm to the plant community because of the oil's long retention time caused by the restricted flow. Since the oil film on the soil surface functions as a physical barrier between air and the soil, it prevents adequate soil aeration. In fact, oil pollution affect the physicochemical properties of the soil such as temperature, structure, nutrient status and pH. Oiled shoots of crops like pepper and tomatoes may wilt and die off due to blockage of stomata thereby inhibiting photosynthesis, transpiration and respiration. In fact, germination, growth performance and yield of these crops stifled by oil spillage.

According to Ukpohwo (2017) in a study on the socioeconomic effects of oil pollution, the exploitation of crude oil has had a negative influence on the soils, forests, and water bodies in host communities in the Niger Delta. Farmers who have lost their farms are compelled to leave their villages in search of work, placing further strain on the natural resources present there.

Iglea (2016) used tabular analysis of data from secondary sources to analyze the environmental effects of oil exploration and exploitation in Nigeria's Niger Delta. The report indicates that although the region's oil sector has significantly boosted the nation's economy, unsustainable oil exploration activities have made the Niger Delta one of the five most badly affected regions in the country.

According to Onwuka (2015), Nigeria has serious environmental issues, especially in the Niger Delta region. Because of the toxicity of oil and gas, the author damages the soil, obliterates fauna, and ruins the habitat for marine fish. Due to incompetence and corruption, the various government programs intended to improve the lot of the farmers have failed. In her report on the

Niger Delta, Katusiime (2009) stated that leaking pipes passing through farms, villages, creeks, and rivers are a significant source of pollution. Farmland contaminated by oil is rarely restored, leading to financial devastation. According to Cohen (2018), the people in the Niger Delta sub-region have been expressing serious grievances for more than 20 years. The flaring gas brought on by crude oil contamination has contaminated their air. Oil spills and pipeline leaks have contaminated their wetlands, streams, and agricultural land.

According to Short, et al. (2012), the Exxon Valdez oil spill in Saudi Arabia occurred thirteen years ago, yet the hazardous impacts are still being felt there because the majority of the less-weathered underground oil is still present. They added that oil spill clean-up operations may cause more harm to a fragile coastal marsh environment than the oil itself. The absorption of petroleum oil into the sediments is one of the main outcomes of petroleum oil spills in the coastal environment.

Edafienene (2012) concluded that the media has little to no influence on risk-related policy decisions in the Niger Delta when looking at the role of the media in such circumstances. Work by Aroh et al. (2010) evaluated cases of pipeline vandalism and oil spills in Nigeria between 1970 and 2006 and looked at the possible risk that these actions posed to the general public's health. However, none of these research examined whether successful risk communication for public health had occurred, and they generally ignored the frameworks and procedures that support risk communication.

There have been numerous oil leak occurrences in Nigeria, which have happened in various regions of the nation at various times or simultaneously. Nigeria has many oil leak incidents throughout the years, but the most notable one was the one on January 17th, 1980, which was said to have had an estimated spill volume of 37.0 million liters and was brought on by a blow out at Funiwa 5 offshore station (Nwilo and Badejo, 2015).

To assist in calculating the risks brought on by oil spills in the environment, Smith et al. (2012) created an oil spill risk analysis model. Even though it was automated, the model was used to examine both the likelihood that a spill would occur and the routes that it would take. The model output contained conditional impact probability tables and likelihood for oil spill occurrences. They used a sample of 500 incidents per season.

The oil spills in Nigeria should be addressed, and both the oil operators and the government should adopt a constructive attitude in order to lessen the health risk posed by these spills, according to Olujobi et al(2018) .'s use of descriptive legal analysis and secondary data sources. The collection of polarimetric data was used by Gambardella et al. (2015) to create a vector of covariance matrix elements, along with the accompanying variances. They came to the conclusion that wind speed can influence polar dependence sensitivity and that their approach can help describe oil. According to Ohanmu et al. (2018), who used a randomized block design to determine changes in the physicochemical parameters and heavy metals content of crude oil-polluted soil, crude oil has an impact on soil qualities throughout the year. According to Moreira et al(2014) .'s evaluation of the temporal and spatial effects of an oil spill on the shore, which

included toxicity tests in the lab, the biomarkers were found to be sensitive to exposures to this type of pollution.

Adati (2012), however, evaluated oil exploration and spillage in the Niger Delta region of the nation using comparative analysis of secondary data covering periods from 1976 to 2000 on descriptive techniques such as line and bar graphs, and discovered a decrease in oil spillage quantity but an increase in the number and times of oil spills. On the other hand, the research results show that agricultural yield decreased over time as a result of ongoing environmental deterioration brought on by oil spills and oil pipeline vandalism.

But a new study by Sam and Pripch (2017) recommends soil screening and significant financing for clean-up in order to improve contaminated land regulations.

Yelsu (2016) on examining the effects of environmental degradation on human health in nine selected oil communities in Delta State, Nigeria using cluster and principal component analysis, observed that gas flaring has a statistically significant, but dangerous impact on human health in the affected areas giving the high temperature and emission to the atmosphere. Nonetheless, the problem of illegal bunkering and vandalizing petroleum pipelines contribute immensely to oil spillage and degradation of the environment.

METHODOLOGY

Primary sources of data were utilized in this investigation. The method of an interview was used to get the required information from the participants. The socioeconomic traits of the cassava farmers, their inputs and output, the reasons for losses in cassava production, the reasons for oil spills, and the consequences of the spills on the cassava crop, yield, and farmland were all recorded. The study focused on Erhoike, Kokori Ethiope East Local Government region of Delta State as the population of study. The method of simple random sampling was employed in selecting the respondents/participant in the study. The study randomly selected 150 cassava farmers from the community being examined as the respondents/participants of the study.

The data for this study were analyzed in accordance with the predetermined goals of calculating the farmland affected by crude oil spillages, estimating the economic losses brought on by the various degrees of crude oil spillages on crop farms, and population estimation using the approach of ratio estimation.

Ratio Estimation

Researchers may want to use ratio estimation in a sample survey to estimate the ratio of two variables or study participants. Ratio estimation enhances the outcome from sample values to population estimates by using the known population totals for variables. It contrasts the population as a whole with the sample estimate of the variable. In addition, it is known that the regression line of the characteristics of interest y on a supporting variable x is linear and passes through the origin, the population ratio of y to x may be estimated and use in the estimation of the population mean total. Let a random sample of size n be selected from the population size N using the simple random sampling without replacement and the characteristics of interest be y with an assisting variable x. Given that

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (1)$$

$$\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n} \quad (2)$$

Then the relationship that expresses the ratio estimation between both variables is given below

$$R = \frac{\bar{y}}{\bar{x}} = \frac{\frac{\sum_{i=1}^{n} y_i}{n}}{\frac{\sum_{i=1}^{n} x_i}{n}} \quad (3)$$

The ratio estimator of $\hat{R}$ unlike its components, $\bar{x}$ and $\bar{y}$ is biased. That is;

$$E(\hat{R}) \neq R \quad (4)$$

Thus the bias of the $\hat{R}$ can be estimated as

$$B(\hat{R}) = \frac{1-f}{n}\hat{R}\left[C_x^2 - 0.1 \times C_x C_y\right] \quad (5)$$

Where

0.1 (10%) is the maximum allowable error rate in the estimate

$f = \frac{n}{N}$ is the sampling fraction (6)

$C_x = \frac{S_x}{\bar{x}}$ and $C_y = \frac{S_y}{\bar{y}}$ are the coefficient of variation (7)

In this study, the cost effect estimation entails the estimation of the cost associated with the economic loss of farm yield as a result of oil spillage activities. Given ratio estimate$(\hat{R})$, and the total number of cultivated farmland examined (N_j), then the population estimate of the affected area is therefore given below as:

$$N = \hat{R}N_j \quad (8)$$

Also, the economic losses due to crude oil spillages on crop farms can be estimated based on the sample survey.

Let C_j be the economic loss value of farmlands affected by crude oil spillage per farmer. Therefore the estimator of total economic loss value is given below as:

$$C = N\Sigma C_j \quad (9)$$

$\Sigma x = 276$ $n = 55$ $N_j = 276$	$\Sigma y = 53$ $n = 55$	$\Sigma C_j = 2{,}100{,}900$ $n = 55$

Assessing the effect of oil spillage on cassava farm land yield

The average number of total farmland cultivated is $\bar{x}$

Therefore $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} = \frac{276}{55} = 5.02$

$\bar{x} \cong 5\ farmlands/farmer$

This result revealed that in the study, each farmer in the region examined is expected to own at least 5 farmlands of 100ft × 100ft size. This indicates that farming activities in this area is very noticeable and tends to be the major occupation of the inhabitants of the region.

The average area of farmlands affected by oil spillage is $\bar{y}$

Therefore, $\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n} = \frac{53}{55} = 0.96$

$\bar{y} \cong 1\ farmland/farmer$

This result denotes that in each farmer in the region examined is expected to experience at least one farmland contaminated by oil spillage in the agricultural practice.

Therefore the ratio estimate of the affected farmlands to the total cultivated farmlands is given thus as

$$R = \frac{\bar{y}}{\bar{x}} = \frac{\frac{\sum_{i=1}^{n} y_i}{n}}{\frac{\sum_{i=1}^{n} x_i}{n}}$$

$$\hat{R} = \frac{1}{5} = 0.2$$

However, if the ratio, $\hat{R}$, is expressed in percentage (%), the resulting value will be

$\hat{R} = 0.2 \times 100 = 20\%$

This finding indicates that farmers in the area run the risk of having their farmlands poisoned. Additionally, according to the estimate from this study, the result suggests that 20% of farmlands are currently harmed by oil spills, which shows that the influence of oil spills on agricultural damage is growing significantly.

Estimated the total area of crop farms polluted by crude oil spillages

In order to estimate the total area affected by the oil spillage, we employ the equation (8)

$N = \hat{R}N_j$

Recall that $\hat{R} = 0.2$, $N_j = 276$

Therefore, $\hat{N} = 0.2 \times 276 = 55.2\ farmlands$

This outcome has shown that a total of over 55 farmlands have been severely impacted by the soil contamination brought on by local oil spills. The study will also assess the possible economic loss incurred on agricultural practice in the environment because this influence has directly damaged the region's agricultural production and there are likely to be significant costs associated with this incidence.

Assessment of the Economic Loss due to crude oil spillages on crop farms in region

Recall from table 2 that ΣC_j = ₦*2,100,900* and from section 4.2.2, $\hat{N} = 55.2$

Therefore, $C = \hat{N}\Sigma C_j$ = 55.2× ₦2,100,900

C = ₦*115,969,680*

The associated economic loss caused by farmland contamination by crude oil spillage in the region is worth ₦*115,969,680*. This alone could lead to famine and starvation. This is a confirmation of the fact that crude oil spillage pose great threat to our environment.

Assessing the Validity of the estimated result

However, the estimate is somewhat subject to bias and thus, to critically examine the level of biasness of the estimate, the following will provide such report

$B(\hat{R}) = \frac{1-f}{n}\hat{R}\left[C_x^2 - 0.1 \times C_x C_y\right]$

$f = \frac{n}{N} = \frac{55}{276}$

$f = 0.2$

$C_x = \frac{S_x}{\bar{x}}$

But $S_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}}$

$S_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}} = \sqrt{\frac{34.98}{55}} = \sqrt{0.636} = 0.797$

Therefore $C_x = \frac{S_x}{\bar{x}} = \frac{0.797}{5} = 0.16$

Also, $C_y = \frac{S_y}{\bar{y}}$

But $S_y = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n}}$

$S_y = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n}} = \sqrt{\frac{31.93}{55}} = \sqrt{0.581} = 0.762$

Therefore $C_y = \frac{S_y}{\bar{y}} = \frac{0.762}{0.96} = 0.762$

The bias of the ratio estimate is given thus:

$B(\hat{R}) = \frac{1-f}{n}\hat{R}\left[C_x^2 - 0.1 \times C_x C_y\right]$

$B(\hat{R}) = \frac{1-0.2}{55}[0.2(\langle 0.16\rangle^2 - 0.1 \times \langle 0.16 \times 0.762\rangle)]$

$B(\hat{R}) = \frac{0.8}{55}[0.2(0.03 - 0.1 \times 0.12)]$

$B(\hat{R}) = 0.01 \times [0.2(0.03 - 0.012)]$

$B(\hat{R}) = 0.01 \times [0.2 \times (0.018)]$

$B(\hat{R}) = 0.01 \times 0.0036$

$B(\hat{R}) = 0.000036$

$B(\hat{R}) \cong 0.0000$

DISCUSSION OF FINDINGS

The study's findings highlighted the estimated amount of farmland in the investigated area that was impacted by oil spills as well as the corresponding monetary losses as a result of the spills.

A critical assessment of the environmental impact of crude oil spills has been attempted in this work. In light of this, an analysis of earlier, comparable research was conducted to comprehend the idea of crude oil extraction, its effects on the economy, and the consequences of spillage. In this regard, the study was created to investigate the effects of oil spills on agricultural practices in Erhoike-Kokori of the Ethiope East local government area, one of the oil-producing communities in Delta State. A total of 55 small-scale commercial farmers were investigated about their agricultural practices and how often crude oil spills effect crop output. The ratio estimation approach was used to examine the data that was acquired. According to the findings, a farmer in the area is likely to own five farming plots, and it is predicted that at least one of these

farmlands will be contaminated by a crude oil leak. Additionally, it was revealed that an estimated total of over 55 farmlands are currently impacted by oil spills, with an estimated N100 million in economic losses as a result of the contaminated farmlands in the area.

The biasness test of the ratio estimate was undertaken to aid in the statistical significance of the estimates/results, and the result provided a bias of 0.00 suggesting that the results were statistically significant. The study has conclusively shown that inappropriate management of crude oil extraction poses a serious hazard to the ecosystem. According to the report, crude oil spills are hazardous and, if they are not effectively contained, will result in environmental deterioration and subpar agricultural output. Nigeria, a country with a heavy reliance on agriculture and crude oil, is currently suffering from an oil disaster. The study has also shown that if the extraction of crude oil is not properly managed to prevent oil spillage, local agricultural production will continue to experience decline.

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