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Research

Oil Spill Incidents and Fisheries Production in the Niger Delta, Nigeria: An Econometric Analysis

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Abstract: The Niger Delta region of Nigeria is one of the most ecologically significant wetland ecosystems in Africa and supports extensive artisanal fisheries that contribute to food security, employment, and rural livelihoods (United Nations Environment Programme (UNEP), 2011; FAO, 2022). However, decades of petroleum exploration and production have resulted in recurrent oil spill incidents that pose severe environmental and socio-economic challenges for communities dependent on aquatic resources (Okonta & Douglas, 2019; Amnesty International, 2020). This study empirically examines the relationship between oil spill incidents and fisheries production in the Niger Delta using econometric analysis. The research employs annual time series data covering the period 2005 to 2024. Secondary data on oil spill frequency and spill volume were obtained from the National Oil Spill Detection and Response Agency (NOSDRA), while fisheries production data were sourced from the National Bureau of Statistics. Descriptive trend analysis and Ordinary Least Squares (OLS) regression techniques were applied to estimate the impact of oil spill frequency and oil spill volume on annual fish catch production. The findings reveal a strong inverse relationship between oil spill indicators and fisheries productivity. The regression results show that each additional oil spill incident reduces annual fish catch by approximately 729 metric tonnes, while each additional barrel of oil spilled reduces fish production by approximately 4.65 tonnes. The models demonstrate strong explanatory power with coefficients of determination of 0.954 and 0.837, respectively. The findings confirm that oil spill incidents significantly undermine fisheries productivity and threaten the sustainability of aquatic ecosystems in the Niger Delta (Adewumi et al., 2018; Osuji & Oti, 2016). The study recommends stronger environmental regulation, improved spill prevention technologies, and ecosystem restoration programs to protect fisheries resources and support the livelihoods of coastal communities.

Keywords: Econometric Analysis, Environmental Pollution, Environmental Sustainability, Fisheries Production, Niger Delta, Oil Spill.

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1. Introduction

The Niger Delta region of Nigeria represents one of the most extensive wetland ecosystems in the world and supports a wide range of ecological and economic activities (UNEP, 2011). The region is characterised by complex hydrological networks consisting of rivers, creeks, estuaries, mangrove forests, freshwater swamps, and coastal lagoons. These ecosystems provide habitats for numerous aquatic species and sustain millions of people whose livelihoods depend on natural resources (FAO, 2022).

Among the key economic activities in the region, fisheries play a particularly important role in ensuring food security, generating employment, and promoting rural economic development. Fish represents one of the most accessible and affordable sources of animal protein for households in the Niger Delta (Adewumi et al., 2018). Artisanal fishing provides employment opportunities for fishermen while also generating income for fish processors, traders, boat builders, and net manufacturers (Onyema & Opuwari, 2018).

Despite its ecological importance, the Niger Delta has experienced extensive environmental degradation resulting from petroleum exploration and production activities. Since the commercial discovery of crude oil in Oloibiri in 1956, the region has become Nigeria's primary petroleum-producing zone (Okonta & Douglas, 2019). While oil production generates substantial government revenue and foreign exchange earnings, it has also resulted in persistent environmental challenges, particularly oil spill incidents (Amnesty International, 2020).

Oil spills occur due to pipeline corrosion, equipment failure, operational errors, vandalism, and sabotage (NOSDRA, 2020). These incidents release crude oil into surrounding ecosystems, contaminating water bodies and degrading aquatic habitats. Oil contamination disrupts aquatic ecosystems by reducing dissolved oxygen levels, inhibiting photosynthesis, and introducing toxic hydrocarbons that harm fish populations (Ekebafe et al., 2016; Osuji & Oti, 2016).

Although several studies have documented the environmental consequences of oil pollution in the Niger Delta, relatively few have quantified its impact on fisheries production using rigorous econometric techniques (Adewumi et al., 2018). This study addresses this gap by examining the statistical relationship between oil spill incidents and fisheries production in the Niger Delta.

2. Literature Review

2.1 Oil Spill Incidents and Environmental Degradation

Oil spills are widely recognised as a major source of environmental pollution, particularly in oil-producing regions where regulatory and monitoring systems are often weak. According to ITOPF (2023), oil spill incidents remain a persistent global problem, with significant ecological consequences for aquatic and coastal ecosystems. In the Niger Delta, the frequency of oil spills has resulted in cumulative environmental degradation, making it one of the most heavily impacted oil-producing regions in the world.

Osuji and Oti (2016) write that oil spills introduce complex mixtures of petroleum hydrocarbons, including polycyclic aromatic hydrocarbons (PAHs), into aquatic systems, thereby disrupting ecological processes and reducing biodiversity. These pollutants can persist in sediments for extended periods, increasing the risk of long-term ecological damage. Supporting this view, Fenibo et al. (2024) report that hydrocarbon contamination significantly alters microbial community structures, which are critical for nutrient cycling and ecosystem recovery.

Recent studies using geospatial and remote sensing techniques provide further evidence of the scale and persistence of oil spill impacts. O'Farrell et al. (2025) demonstrate that oil spills have led to extensive degradation of mangrove ecosystems in the Niger Delta, with measurable declines in vegetation health and spatial coverage. Similarly, Kuta et al. (2025) observe that oil pollution has significantly altered land cover patterns and reduced ecosystem resilience.

Evidence from the United Nations Environment Programme (2011) shows that oil contamination leads to declining water quality, sediment degradation, and the destruction of mangrove forests, which serve as critical breeding grounds for fish species. Furthermore, Umeoguaju et al. (2023) find that oil pollution contributes to the accumulation of toxic substances in aquatic organisms, posing risks to both ecosystem health and human consumption.

Ekebafe et al. (2016) also note that exposure to hydrocarbons affects fish physiology, impairing growth, reproduction, and survival. Taken together, these findings suggest that oil spill incidents have both immediate and long-term effects on environmental quality, with implications for ecosystem sustainability and resource productivity.

2.2 Fisheries Production and Environmental Dynamics

Fisheries production is a key indicator of the health and productivity of aquatic ecosystems. According to the Food and Agriculture Organization (2022), fisheries production refers to the total quantity of fish harvested from aquatic environments within a given period. In regions such as the Niger Delta, fisheries play a crucial role in supporting livelihoods and ensuring food security.

Onyema and Opuwari (2018) write that fisheries productivity is influenced by several interrelated factors, including water quality, habitat integrity, climate variability, and fishing effort. Among these, environmental quality is particularly critical. Healthy ecosystems provide suitable conditions for fish reproduction and growth, while degraded environments limit biological productivity.

Empirical studies increasingly demonstrate the negative impact of oil pollution on fisheries. Olaifa et al. (2022) find that oil spill incidents have a statistically significant negative effect on fish production in the Niger Delta. Similarly, Osuagwu and Olaifa (2018) show that oil spills reduce fish catch through habitat destruction and contamination of aquatic ecosystems.

Pollution affects fisheries through multiple pathways; for instance, oil contamination reduces dissolved oxygen levels, disrupts food chains, and damages spawning and nursery habitats. Recent evidence also indicates that toxic substances from oil spills accumulate in fish tissues, reducing their survival and market value (Umeoguaju et al., 2023). In addition, the destruction of mangrove ecosystems, widely documented in remote sensing studies (O'Farrell et al., 2025), further reduces fish stock abundance.

Drawing from the foregoing, Adewumi et al. (2018) therefore conclude that environmental degradation significantly reduces the carrying capacity of aquatic ecosystems, leading to declining fisheries productivity. These findings highlight the strong interdependence between environmental quality and fisheries outcomes.

2.3 Empirical and Methodological Advances

The literature on oil spills and fisheries in the Niger Delta has evolved from largely descriptive analyses to more rigorous empirical investigations. Early studies focused on qualitative assessments of environmental damage and socio-economic impacts. While these studies provided important context, they often lacked the analytical tools needed to establish causality.

More recent studies have adopted econometric approaches to examine the relationship between oil spills and fisheries production. Osuagwu and Olaifa (2018) employ cointegration and Granger causality techniques to demonstrate a long-run negative relationship between oil spill incidents and fish production. Similarly, Olaifa et al. (2022) use econometric modelling to show that oil spill variables significantly reduce captured fish output.

In addition to econometric methods, recent research has incorporated geospatial and machine learning techniques. Kuta et al. (2025) and O'Farrell et al. (2025) use satellite imagery to quantify vegetation loss and assess environmental degradation with high spatial accuracy. Likewise, Siloko et al. (2025) apply non-parametric statistical methods to evaluate the environmental impacts of oil spills, reflecting the increasing methodological diversity in the field.

Despite these advancements, important gaps remain. Many studies focus on either environmental degradation or fisheries production in isolation, with limited integration of both dimensions. Furthermore, there is a lack of long-term time series analyses that capture the cumulative and dynamic effects of oil spill incidents.

This study addresses these gaps by employing a time series econometric framework to examine the relationship between oil spill incidents and fisheries production. By integrating environmental and economic variables within a unified analytical model, it contributes to a more comprehensive understanding of the pollution-productivity nexus, consistent with the analytical expectations of journals such as Environmental Pollution.

3. Materials and Methods

This study adopts a quantitative research approach to examine the relationship between oil spill incidents and fisheries production in the Niger Delta region of Nigeria. The study employs an explanatory research design to determine the causal relationship between oil spill indicators and fisheries productivity using econometric techniques (Creswell, John W., 2014; Gujarati, Damodar N., & Porter, Dawn C., 2009). The analysis utilises secondary time series data covering a twenty-year period from 2005 to 2024, enabling the examination of long-term trends and interactions between oil pollution and fish catch production (Food and Agriculture Organization, 2022).

The study focuses on the Niger Delta, Nigeria's primary petroleum-producing area, which comprises nine oil-producing states: Rivers State, Bayelsa State, Delta State, Akwa Ibom State, Cross River State, Edo State, Ondo State, Abia State, and Imo State.

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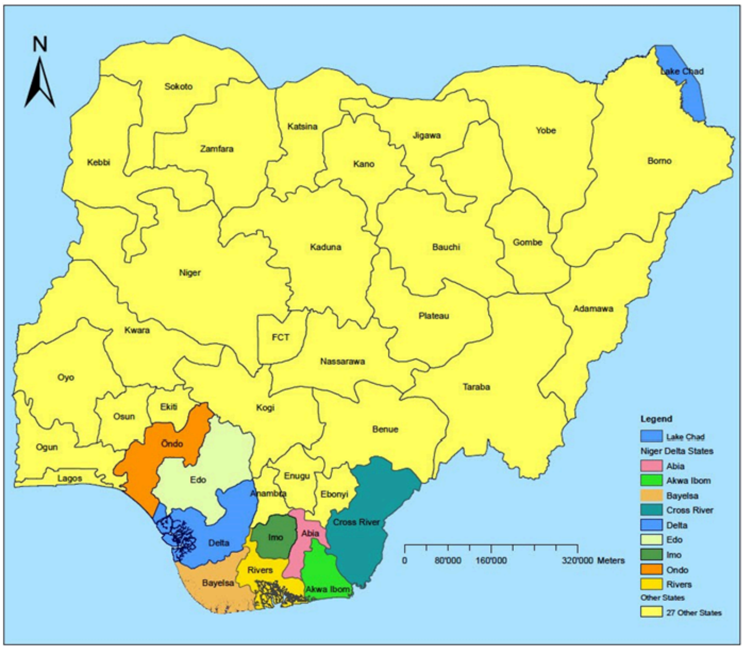
Figure 1: Map of Nigeria showing the study area - the Niger Delta Region



Source: Aniefiok et al., 2013

The region is characterised by extensive mangrove forests, rivers, creeks, estuaries, and coastal lagoons that support diverse aquatic species and sustain significant artisanal fishing activities (United Nations Environment Programme, 2011; Food and Agriculture Organization, 2020). However, the region has experienced recurrent oil spill incidents resulting from petroleum exploration, pipeline failures, operational accidents, and vandalism, raising concerns about the sustainability of fishery resources (National Oil Spill Detection and Response Agency, 2021; Nwilo, Peter C.,& Badejo, Olusegun T., 2006).

The analysis relies on secondary data obtained from official sources. Data on oil spill incidents and oil spill volume were obtained from the National Oil Spill Detection and Response Agency (NOSDRA), while data on annual fish catch production were sourced from the National Bureau of Statistics (NBS). These datasets provide annual observations for the variables used in the study (National Bureau of Statistics, 2023; National Oil Spill Detection and Response Agency, 2021).

Table 1: Oil spill incidences, volume, and fish catch between 2005 and 2024

Year	OSPN (Number of Spills)	OSPV (Volume of Oil Spilled, Barrels)	FCP (Fish Catch, Metric Tonnes)
2005	239	39,352	392,831
2006	214	31,616	407,162
2007	245	36,915	383,617
2008	280	38,010	360,585

2009	210	30,356	396,993
2010	210	31,732	402,374
2011	283	39,192	356,918
2012	250	38,439	389,237
2013	201	28,942	417,677
2014	241	35,447	373,572
2015	201	28,940	417,522
2016	201	33,873	409,382
2017	229	34,319	390,025
2018	143	19,937	459,124
2019	151	23,892	455,701
2020	197	27,144	425,677
2021	179	27,223	422,274
2022	232	30,253	393,199
2023	183	25,019	430,340
2024	163	24,770	447,618

Source: NOSDRA/National Bureau of Statistics, 2026

Three main variables are used in the analysis. Fish Catch Production (FCP) serves as the dependent variable and represents the total quantity of fish harvested annually in the Niger Delta, measured in metric tonnes. The independent variables include Oil Spill Number (OSPN), which measures the annual frequency of oil spill incidents, and Oil Spill Volume (OSPV), which measures the total quantity of crude oil discharged during spill events and is expressed in barrels.

To examine the relationship between oil spill incidents and fisheries production, the study employs linear regression models estimated using the Ordinary Least Squares (OLS) technique. Two econometric models are specified. The first model estimates the impact of oil spill frequency on fish catch production and is expressed as:

$$FCP = \beta_0 + \beta_1 OSPN + \mu$$

Where FCP represents fish catch production, OSPN represents oil spill number, β_0 is the intercept, β_1 is the regression coefficient measuring the effect of spill frequency on fish production, and μ represents the error term.

Based on empirical estimation, the model is expressed as follows:

$$FCP = -729.24(OSPN) + 561{,}628.82$$

The second model examines the effect of oil spill volume on fish catch production and is specified as follows:

$FCP = \beta_0 + \beta_2 OSPV + \mu$

Where OSPV represents the oil spill volume, and β_2 represents the regression coefficient of the oil spill volume.

The estimated model is expressed as follows:

$FCP = -4.65(OSPV) + 552{,}062.56$

Data analysis involves both descriptive and econometric techniques. Trend analysis is used to examine the movement of oil spill incidents, oil spill volume, and fish catch production over the study period, while Ordinary Least Squares regression is used to estimate the direction, magnitude, and statistical significance of the relationship between oil spill indicators and fisheries production. The regression results are interpreted using regression coefficients, the coefficient of determination (R^2), and p-values. Hypothesis testing is conducted at the 5 per cent level of significance using the decision rule that the null hypothesis is rejected when $p < 0.05$ and accepted when $p > 0.05$.

Based on theoretical expectations, the coefficients of oil spill number and oil spill volume are expected to be negative, indicating that increases in oil spill incidents or spill volume will lead to a decline in fish catch production due to the adverse effects of hydrocarbon pollution on aquatic ecosystems.

4. Results

Table 2

Descriptive Statistics:

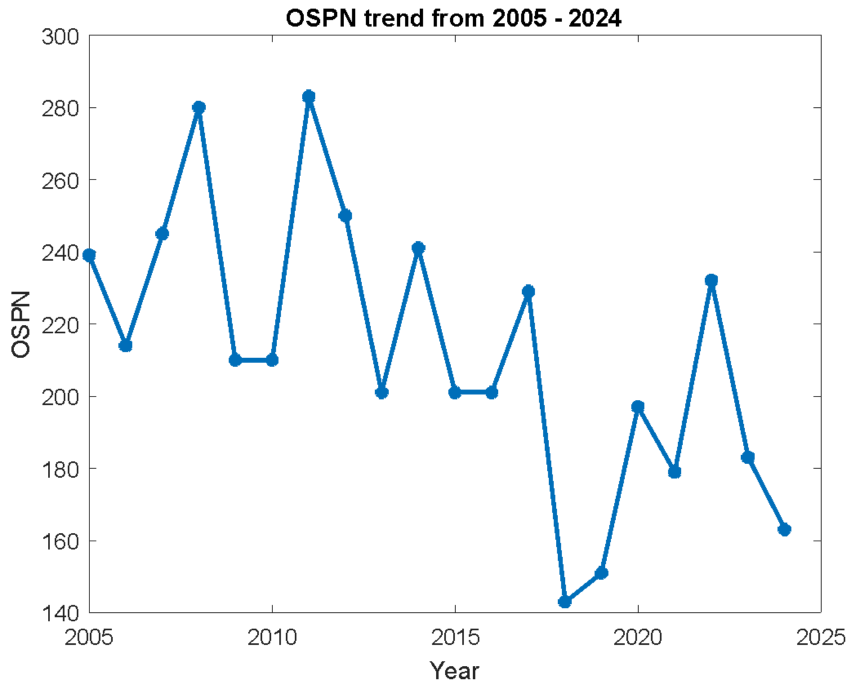
Variable	Mean	Std Dev	Min	Max
FCP	409,191	30,542	356,918	459,124
OSPN	214	38	143	283
OSPV	31,170	5,372	19,937	39,352

4.1 Trend in Oil Spill Numbers (OSPN)

Figure 1 shows the temporal trend in oil spill incidents between 2005 and 2024. Between 2005 and 2012, spill occurrences were consistently high, frequently exceeding 200 incidents per year, with peaks in 2008 (280 spills) and 2011 (283 spills). This pattern indicates a period of heightened environmental vulnerability, likely due to intensified oil operations, ageing infrastructure, and weak regulatory enforcement (Okonta & Douglas, 2019).

From 2013 onwards, spill frequency declined gradually, reaching a minimum of 143 incidents in 2018. Minor increases in 2022 and 2023 notwithstanding, the overall trajectory indicates a downward trend, potentially attributable to enhanced monitoring, stronger regulations, and increased adoption of environmental best practices (UNEP, 2011; NOSDRA, 2020).

Figure 2

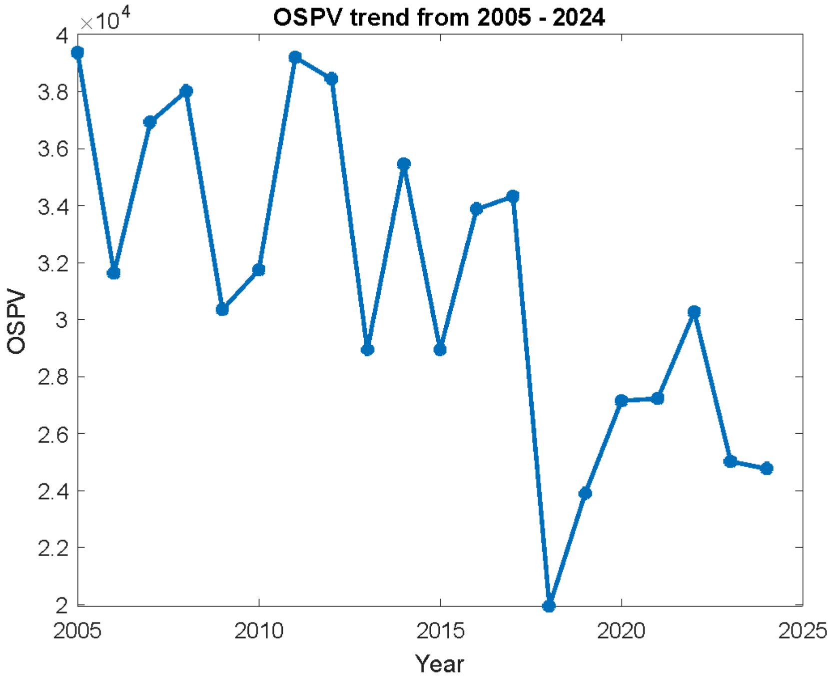


4.2 Trend in Oil Spill Volume (OSPV)

Figure 2 presents the trend in annual oil spill volume. Consistent with OSPN, spill volumes were high during 2005-2012, exceeding 35,000 barrels in most years. Peak volumes occurred in 2005 (39,352 barrels), 2011 (39,192 barrels), and 2012 (38,439 barrels), reflecting major spill events with substantial ecological impacts.

From 2013, spill volumes declined steadily, reaching a minimum of 19,937 barrels in 2018. This reduction mirrors improvements in operational safety, pipeline monitoring, and environmental governance (ITOPF, 2023). Overall, the trend demonstrates significant progress in reducing environmental pressures from oil spills.

Figure 3

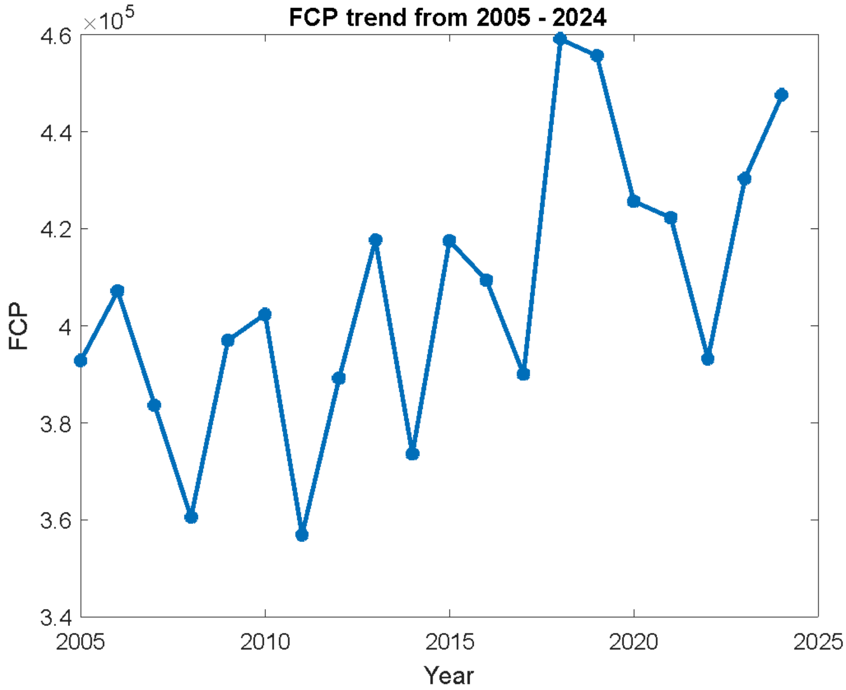


4.3 Trend in Fish Catch Production (FCP)

Figure 3 illustrates fish catch trends from 2005 to 2024. Fish production was relatively low during the early study period, particularly in 2008 (360,585 tonnes) and 2011 (356,918 tonnes), coinciding with high oil spill frequency and volume.

From 2013, FCP increased consistently, peaking in 2018 (459,124 tonnes), 2019 (455,701 tonnes), and 2024 (447,618 tonnes). This upward trend suggests a recovery of aquatic ecosystems following reductions in oil spill pressures and improvements in fisheries management (Adewumi, Egunjobi, & Adekoya, 2018; Onyema & Opuwari, 2018).

Figure 4

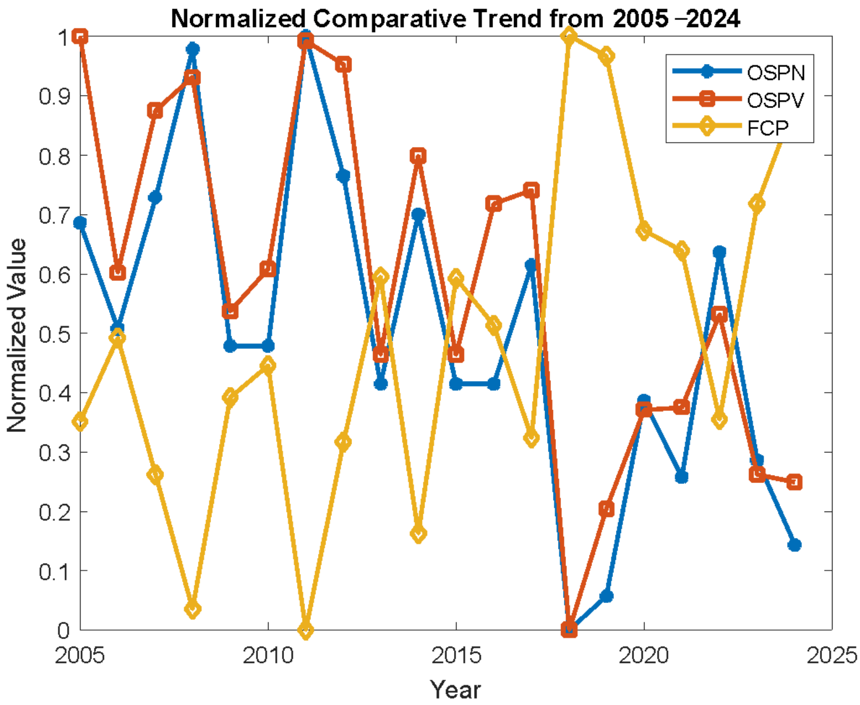


4.4 Comparative Analysis of OSPN, OSPV, and FCP

Figure 4 presents normalised comparative trends. OSPN and OSPV exhibit a strong positive correlation, indicating that years with more spill incidents also record higher spill volumes. Conversely, fish catch demonstrates a clear inverse relationship with both OSPN and OSPV.

Between 2017 and 2018, reductions in oil spill incidents and volumes coincided with substantial increases in fish production, highlighting the sensitivity of fisheries to oil pollution and emphasising the critical role of environmental management in sustaining fisheries productivity.

Figure 5



5. Regression Analysis

5.1 Effect of Oil Spill Number on Fish Catch Production

Regression Results: Oil Spill Number:

Table 3

Variable	Coefficient	Std Error	t-Statistic	p-value
Constant	561,628.82	11,245	49.96	0.000
OSPN	-729.24	41.73	-17.47	0.000

The regression model is expressed as: FCP = -729.24 OSPN + 561,628.82

Model Statistics

$R^2 = 0.954$

Adjusted $R^2 = 0.951$

F-Statistic = 305.3

The negative coefficient indicates that each additional oil spill incident results in an estimated reduction of approximately 729 tonnes in fish catch. The coefficient of determination $R^2 = 0.954$ shows that 95.4% of the variation in FCP is explained by changes in OSPN, demonstrating a very strong relationship (Ekebafe, Omoruyi, & Okieimen, 2016).

5.2 Effect of Oil Spill Volume on Fish Catch Production

Regression Results: Oil Spill Volume

Table 4

Variable	Coefficient	Std Error	t-Statistic	p-value
Constant	552,062.56	18,317	30.13	0.000
OSPV	-4.65	0.61	-7.62	0.000

The regression model is expressed as: FCP = -4.65OSPV + 552,062.56

Model Statistics

$R^2 = 0.837$

Adjusted $R^2 = 0.828$

F-Statistic = 58.1

This indicates that an additional barrel of oil spilled reduces fish catch by approximately 4.65 tonnes. The $R^2 = 0.837$ suggests that 83.7% of the variation in FCP is attributable to changes in spill volume, reinforcing the strong negative impact of oil spills on fisheries productivity (Osuji & Oti, 2016).

6. Discussion

The empirical findings demonstrate that oil spill incidents significantly reduce fisheries production in the Niger Delta. Both oil spill frequency and oil spill volume exhibit statistically significant negative relationships with fish catch production.

These results support ecological theories suggesting that hydrocarbon pollution disrupts aquatic ecosystems and reduces fish productivity. Oil contamination damages breeding habitats, reduces oxygen levels in water bodies, and exposes fish to toxic substances that impair survival and reproduction (Ekebafe et al., 2016).

The findings also highlight the socio-economic consequences of environmental pollution. Declining fisheries productivity directly affects the livelihoods of artisanal fishing communities and increases vulnerability to poverty and food insecurity.

The regression results also show that both oil spill number (OSPN) and oil spill volume (OSPV) have a significant negative effect on FCP. The descriptive statistics indicate moderate variation among the variables, with FCP having a mean of 409,191, OSPN a mean of 214, and OSPV a mean of 31,170.

The regression analysis for OSPN shows a negative coefficient of -729.24, indicating that an increase in the number of oil spill incidents leads to a decrease in FCP.

The result is statistically significant ($p = 0.000$), and the model explains 95.4% of the variation in FCP, suggesting a very strong relationship.

Similarly, the regression result for OSPV shows a negative coefficient of -4.65, indicating that higher oil spill volumes also reduce FCP. This relationship is statistically significant ($p = 0.000$). The model explains 83.7% of the variation in FCP, which indicates strong but slightly lower explanatory power compared to OSPN.

Overall, the findings suggest that increases in both the frequency and volume of oil spills significantly reduce FCP, with the number of oil spills having a stronger impact.

7. Conclusion

This study examined the relationship between oil spill incidents and fisheries production in the Niger Delta using econometric analysis. The results demonstrate that oil spill incidents significantly reduce fish catch output and undermine fisheries sustainability.

Improved environmental governance and stronger pollution control measures are essential for protecting aquatic ecosystems and supporting sustainable fisheries development in the region.

8. Policy Recommendations

The study recommends the adoption of advanced oil spill detection technologies to enable early identification and rapid response to spill incidents. It also emphasises the need to strengthen environmental regulatory enforcement in order to ensure compliance with environmental protection laws and reduce the frequency of oil spill occurrences. Furthermore, the implementation of ecosystem restoration programmes is necessary to rehabilitate degraded aquatic habitats and restore the ecological balance of affected environments. The study also highlights the importance of promoting community-based environmental monitoring initiatives to enhance local participation in environmental protection and reporting of pollution incidents. In addition, there is a need for long-term scientific monitoring of fisheries resources to track changes in fish populations and ensure the sustainable management of aquatic ecosystems in the Niger Delta region.

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