



Vol. 12(3), Pp. 58-64, October 2024,

Author(s) retain the copyright of this article

This article is published under the terms of the
Creative Commons Attribution License 4.0.

<https://journals.directresearchpublisher.org/index.php/drjafs>

Research Article
ISSN: 2354-4147

The Causes, Effects, and Determinants of the Farmers' Technical Efficiency in the Cassava Farms Affected by the Spilt Crude Oil in the Eneka Community in River State

Victor Chiabuotu Kalu^{1*}, ThankGod Peter OJimba², Godwill Ibim Wilcox³ and Raymond Chukwuemeka Obi⁴

¹Department of Agricultural Economics and Extension, Ignatius Ajuru University of Education, Rumuolumeni, Rivers State, Nigeria.

²Department of Agricultural Economics and Extension, Ignatius Ajuru University of Education, Rumuolumeni, Rivers State, Nigeria.

³Department of Agricultural Economics and Extension, Ignatius Ajuru University of Education, Rumuolumeni, Rivers State, Nigeria.

⁴Department of Agricultural Economics and Extension, Ignatius Ajuru University of Education, Rumuolumeni, Rivers State, Nigeria.

*Corresponding Author's email: kaluvictor96@gmail.com

ABSTRACT

The study considered the causes, effects, and determinants of the farmers' technical efficiency in the cassava farms affected by the spilt crude oil in the Eneka community in Rivers State. A sample size of 48 respondents was selected using a multistage sampling procedure. Data were collected through scheduled interviews and observations using a structured questionnaire. The analysis used descriptive statistics and the Cobb-Douglas Stochastic Frontier Production Function. The study revealed that 79.17% of individuals involved in cassava production in crude oil spilt farms were males, while 20.83% were females. Additionally, more than 91% of the cassava farmers interviewed were under 60, with an average age of 47. Over 78% of the farmers were married. The majority of the sampled cassava farmers had an average farming experience of over 13 years and an average household size of 6 persons. The results of the Stochastic production function showed that technically inefficient variables of gender, education, marital status, household size, farming experience, labour, and farm size were statistically significant at 1%, in the area. Results further showed that crude oil spillage in the study area occurred because of sabotage (crude oil bunkering) (87.50%), giving rise to increased soil toxicity (97.92%), degradation of farmland, reduction of soil fertility (95.83%), low land productivity, decaying of tubers, poor yield, stunted growth, high level of food shortage, poor harvest and low income. This study concluded that crude oil spillage had detrimental and negative effects on cassava farms' quality of output, income, and the area of cropped farmland. Some recommendations were made, including immediate response to an oil spill, proactive measures in dealing with oil spillage, improving the security of various installations to prevent the vandalization of pipelines, and constant environmental monitoring and evaluation to determine the level of damage.

Keywords: Cassava farmers, crude oil, spillage, causes, effects, Eneka Community

Article information

Received 7 September 2024;

Accepted 20 October 2024;

Published 25 October 2024

<https://doi.org/10.26765/DRJAFS15297917>

Citation Kalu, V. C., OJimba, T.P., Wilcox, G. I., and Obi, R. C. (2024). The Causes, Effects, and Determinants of the Farmers' Technical Efficiency in the Cassava Farms Affected by the Spilt Crude Oil in the Eneka Community in River State. Direct Research Journal of Agriculture and Food Science. Vol. 12(3), Pp. 58-64.

This article is published under the terms of the Creative Commons Attribution License 4.0.

INTRODUCTION

Crude oil spillage has to do with the release of crude oil into the environment during transportation, production or storage. Essien and John (2010) observed that the

hydrocarbons found in crude oil spillage are large and complex molecules, and persistent and may require a strong reagent to counteract their effects on agricultural

soil. The continued depletion of cassava farmlands by oil companies in Rivers State through oil spillage is just an instance of buttressing the myriads of undermining situations faced by the cassava farmers in Nigeria (Abah et al., 2020). Nwachukwu and Ekanem (2016) noted that an oil spill is simply the release of a liquid petroleum hydrocarbon into the environment due to human activities and equipment failure. It can affect the environment in different ways. Ojimba (2011) observed that the magnitude of the impact could be dependent on the type of accident (blowouts, explosions, pipeline rupture). Oil spills often happen because of accidents, when people make mistakes or equipment breakdowns. Other causes include natural disasters or deliberate acts (pipelines vandalization).

Oil spillage in Nigeria can be a natural cause or a human cause. Although, a third cause can be said to be the mysterious cause (Ifeoma et al., 2019). According to the report, natural spill causes are those spills that come naturally, that is, they occur naturally. Examples include the vandalization of oil pipes which could bring about spillage, carelessness on the side of both workers (this is an operational cause), or the tanker drivers (accidents can happen during delivery).

Kalu et al. (2024) observed that the effect of oil spillage on cassava cultivation can be significant and multifaceted, particularly in regions where cassava is the primary crop. Oil spills can lead to the contamination of soil, affecting its structure and composition. The presence of hydrocarbons can harm soil microorganisms essential for nutrient cycling, potentially reducing soil fertility and adversely impacting crop yield. Cassava is a tuberous crop that absorbs nutrients and water through its roots. Oil contaminants can inhibit this absorption process. Roots may also absorb harmful compounds from the soil, which could lead to phytotoxicity, resulting in poor growth, deformities in tubers, and lower harvest quality. Oil spills can contaminate local water sources used for irrigation. Polluted water can lead to further exposure of cassava plants to harmful substances.

Additionally, the presence of oil in water can affect its availability, making it challenging for farmers to maintain adequate irrigation practices. Efforts to remediate oil-contaminated soil can be complex and costly [Kalu, 2022]. Techniques such as bioremediation or chemical clean-up may be required to restore soil health, but these may not provide immediate relief to farmers facing diminished crop yields. Farmers often lack access to technical knowledge on effective remediation techniques and may face financial constraints in acquiring quality organic amendments.

Farmers facing the detrimental effects of oil spillage on cassava cultivation often implement a variety of measures to mitigate the situation, although their effectiveness may vary based on technical efficiency, available resources, and support systems.

According to Essifile and Crentsil (2014), an entrepreneur's technical efficiency can be measured by comparing actual production to potential or ideal production. The specific technical efficiency of a firm is determined by the differences between observed outputs and the best or most efficient production possible (Wilcox et al., 2024). Anang et al (2016) stated that the variations in a firm's technical efficiency can be attributed to a variety of non-technical factors, as well as managerial skill, the use of different levels of technology, and environmental circumstances. Mussa et al (2020) suggested that technical efficiency can be improved through enhanced production techniques, indicating that as production technology advances, factor proportions will change due to substitution under a particular technology. This implies a shift in the production process itself, leading to more production with the same number of resources or increased production with fewer resources than before. Various methods are used to measure technical efficiency and productivity, such as the Cobb-Douglas production function, data envelopment analysis (DEA), total factor productivity indices (TEPI), least squares econometric production models (LSEPM), and stochastic frontier production function (SFPF) (Ogundari, 2006).

A study was conducted by Abah et al. (2020) to investigate the effects of oil spillage on cassava farmers' livelihoods. The study revealed that pipeline vandalization was identified as the major cause (88%) of oil spillage in the study area. In 2013, Ahmadu and Egbodion examined the effects of oil spillage on cassava farmland, yield, and productivity. The results showed that the major significant effects of oil spillage on cassava production perceived by the farmers included crop failure, poor yield, rotting tubers, and stunted crop growth with mean scores of 4.80, 4.78, and 4.75 respectively. Others included increased soil temperature and toxicity (mean 4.73), reduction of soil fertility (mean 4.70), and low land productivity. The results further indicated that the cassava farm size, yield, and land productivity in oil spillage-affected communities were significantly lower. These represent a significant reduction of 36.48% and 20% of these variables in the oil spillage-affected communities respectively. About 45% of the land productivity in cassava production was influenced by oil spillage and the farmers' farming experience; the productivity increased with an increase in farming experience but decreased with an increase in oil spills. Cassava is important, not just as a food crop but even more so as a major source of income for producing households. As a cash crop, cassava generates cash income for the largest number of households, compared with other staples, contributing positively to poverty alleviation (Ojimba 2011). Cassava likes light, sandy loam soils with medium soil fertility and with good drainage. Saline, strongly alkaline, and stony soils, and

soils with stagnant water are unsuitable for the cultivation of cassava. Stony soils inhibit the formation of the root tuber. Where soil fertility is concerned, cassava is easily satisfied. Even in impoverished and acidic soils that are unsuitable for the cultivation of other plants, cassava will still provide a relatively good crop. In Eneka, oil spills have been seen as a major threat to the environment, which has led to the total annihilation of the ecosystem. The study was therefore carried out to ascertain the following objectives: examine the causes of crude oil spillage on cassava farms in the Eneka community, determine the effects of crude oil spillage on cassava farms and determine of the technical efficiency of the cassava farmers.

MATERIALS AND METHODS

The research involved surveying and collecting data through structured questionnaires and scheduled interviews. The focus of the research was the Eneka Community located at latitude 40N 531 5811 and longitude 70E 11 5911, in the Obio/Akpor Local Government Area of Rivers State. In the Eneka Community, the main cropping systems are sole cropping, mixed cropping, and intercropping, while farming practices are traditional, with the use of crude implements like hoes and cutlasses. Agricultural production is on a subsistence scale, with small farm holdings and crops such as cassava, yam, plantain, and vegetables.

A total of 48 persons were selected for the study using a multistage sampling procedure. The community was divided into farming areas as the first stage. In the second stage, the cassava farmers were randomly stratified into polluted and non-polluted cassava farm respondents. In the third stage, simple random sampling was used to select 48 oil-polluted cassava farms from the community. Data collected were analyzed using descriptive statistics and stochastic frontier production function.

Stochastic frontier production analysis

The Cobb-Douglas functional form was chosen because it is frequently used to calculate factors and farm productivity in both developed and developing nations and it meets the requirement of being self-dual, allowing an examination of economic efficiency (Wilcox et al., 2024) The Stochastic frontier production function was used to achieve objective iii. It was specified implicitly as:

$$Y_i = f(X_i, \beta_i) + e_i \quad \text{Eq (1)}$$

$$e_i = V_i - U_i \quad \text{Eq (2)}$$

where:

$$Y_i = \text{quantity of output of the } i^{\text{th}} \text{ farm}$$

X_i	=	vector of the inputs used by the i^{th} farm
β_i	=	a vector of the parameters to be estimated
e_i	=	composite error term
v_i	=	random error outside the farmer's control
and		
$-u_i$	=	technical inefficiency effects

The stochastic frontier production function model used in the study is specified explicitly as:

$$\text{Log } Y = \text{Log} \beta_0 + \beta_{1\text{Log}} X_1 + \beta_{2\text{Log}} X_2 + \beta_{3\text{Log}} X_3 + \beta_{4\text{Log}} X_4 + \beta_{5\text{Log}} X_5 \quad \text{Eq (3)}$$

Where:

Log	=	the natural logarithm
Y	=	output of cassava (kg/ha)
β_0	=	Constant term
$\beta_1 - \beta_6$	=	Regression coefficients to be estimated
X_1	=	Labour used [in man/days]
X_2	=	farm size[kg/ha]
X_3	=	causes of oil spillage
X_4	=	Impact of oil spillage on farmland
X_5	=	Impact of oil spillage on crops
V_i	=	random variability in the production that cannot be influenced by the farmer

$-u_i$ = Socio-economic variables [technical inefficient effects

$$-U_i = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 \quad \text{Eq (4)}$$

Where:

$-U$	=	Inefficiency effects,
Z_1	=	Age (years)
Z_2	=	Household size (number)
Z_3	=	Formal education (years)
Z_4	=	Farming experience (years)
Z_5	=	Gender
Z_6	=	Marital status
β_0	=	Constant term
$\beta_1 - \beta_6$	=	Parameters to be estimated

RESULTS AND DISCUSSION

Socioeconomic characteristics of cassava farmers in Eneka

In Table 1, the gender distribution of the farmers is depicted. In farms affected by crude oil spill, 79.17% of the farmers were males, while only 20.83% were females. This suggests that there were more male farmers. The study's results indicate the agricultural setting in the study area, where males have greater access to land for farming and other activities compared to females (Ojimba & Iyagba, 2012). Age has a direct bearing on the productivity of farm labour and the ease with which improved agricultural practices are adopted.

Table 1: Socioeconomic characteristics of farmers in the study area.

Variables		Frequency (Per 100)	Percentage	Mean
Gender	Male	38	79.17	
	Female	10	20.83	
Age (years)	Less than 30	1	2.08	
	30 – 39	6	12.50	
	40 – 49	22	45.83	
	50 – 59	15	31.25	
	60 – above	4	8.34	47
Educational level	No formal education	11	22.92	
	Primary	15	31.25	
	Secondary	20	41.66	
	Tertiary	2	4.17	
Household size	Less than 4 persons	8	16.67	
	4 – 6 persons	23	47.93	
	7 – 9 persons	15	31.25	
	10 persons & above	2	4.16	6
Farming experience (yrs)	Less than 11	13	27.08	
	11 – 20 yrs	27	56.25	
	21 yrs & above	8	16.67	14yrs

Source: Field survey, 2024.

Table 1 shows that about 91% of the farmers were less than 60 years of age with an average age of 47 years. The oil spills in the community degraded the farmland for cassava production, worsening the rural-urban migration of the youth from the community, and leaving farming to older people (Ahmadu and Egbodion, 2013). Table 1 shows the educational levels attained by farmers in the study area. The education levels attained by farmers significantly impact productivity, income-earning opportunities and poverty level. This implies that the educational level of the farmer is reducing technical inefficiency thereby increasing technical efficiency. Table 1 shows the respondents' distribution based on their household size. It reveals that 47.93% of the farmers had a household size of 4-6 persons with a mean household size of 6 persons. Regarding farming experience, the result implies that the respondents had been involved in agricultural production for a long time and must have had several experiences with the effects of crude oil spillage on agricultural production in the study area.

Impact on farmers' livelihoods in crop production

Farm size of the farmers

The results indicate that over 83% of the farmers in the Eneka community were small-scale farmers cultivating less than 3.0 hectares of farmland. This aligns with the findings of Ojimba [2005]. Therefore, any form of crude oil pollution or spillage will drastically affect many of them, which could further impoverish the peasant farmers. There is a likelihood of poverty occurrence in households cultivating small farm sizes, worse still if such household farms are affected by oil pollution of any

magnitude.

Quantity of cassava produced among surveyed farmers

The result agrees with the findings of Iheke et al. (2019) that oil spillage has a negative and significant impact on productivity. This means that oil spillage significantly reduces agricultural productivity. Ojimba et al. (2014) said that crude oil pollution on crop farms reduced crop output significantly, hence detrimental to crop production (Table 2).

Analysis of causes and impacts of crude oil spillage on cassava farms causes of crude oil spillage

The result shows that 97.92% of respondents agree to the fact that sabotage of the pipelines was the main cause of oil spillage on cassava farms in the Eneka community (Table 3). The loss was a result of illegal oil bunkering. Chikaire et al. (2015) noted that illegal fuel siphoning has increased the number of oil pipeline explosions in recent years due to the thriving black market for fuel products. This result is also in line with Ifeoma et al. (2019), whose study revealed that sabotage had a significant level of 5% with the analysis of variance.

Effects of crude oil spillage on cassava farmland

The results are also in line with Ojimba and Iyagba (2012), who observed that most of the soil where these spills occur suffers from loss of soil fertility through loss of soil organic matter, leaching of nutrients, loss of the nutrient-laden topsoil, changes in soil pH, reduction in

Table 2: Estimated effects on crop production.

Variables	Frequency	Percentage
Farm size (Ha)	0-0.9ha	27.08
	1.0-1.9ha	33.33
	2.0-2.9ha	20.83
	3.0-3.9ha	12.50
	4.0-4.9ha	4.17
	5.0ha above	2.08
	Average	1.90ha
	mean	8.00
	t-value estimated	2.4155 ^{**}
Quantity of cassava produced (kg)	0 – 29kg	25.00
	30 – 59kg	41.67
	60 – 89kg	14.58
	90 – 119kg	10.42
	120 and above	8.33
	Average	55.13kg
		mean
	t-value estimated	3.681 ^{***}

Source: Field Survey, 2024.

Table 3: Causes of crude oil spillage in the study area.

Causes	Frequency [*]	Percentage
Corrosion of oil pipeline	3	6.25
Drilling of oil wells	1	2.08
Natural cause	1	2.08
Sabotage	47	97.92
Unknown sources	1	2.08

Source: Field Survey, 2024 * Multiple response

Table 4: Effects of crude oil spillage on cassava farmland in the study area.

Impacts of Crude Oil Spillage in farmland	Frequency [*]	Percentage	Ranking
Increased soil toxicity	47	97.92	1 st
Reduction of soil fertility	46	95.83	2 nd
Poor land productivity	45	93.75	3 rd
Degradation of farmland	40	83.33	4 th
Poor soil aeration	38	79.17	5 th

Source: Field Survey, 2024. * Multiple response

cation exchange capacity, salinization, waterlogging, and other forms of soil degradation are major problems associated with agricultural productivity in the soil (Table 4).

Cobb-Douglas stochastic frontier analysis of spilled farms

The results of crude oil spilt farms showed that the stochastic frontier production factors were statistically significant at a probability of 0.05 and 0.10 respectively. The negative value of the labour coefficient (-3.165), significant at $P < 0.10$, indicated that if farm labour (X_1) is increased by 10%, the output will decrease on cassava farms by 31.65% [elastic decrease]. This could be because hiring labour for various farm activities was

expensive and the farmers could not really afford such increased expenditure, though very necessary to help cultivate crude oil spilt area (Tables 5a and b). The coefficient of farm size [ha] was negative (-1.527) and was statistically significant at $p < 0.05$. This means that farm size (X_2) was reduced because of the negative effect of the spilt crude oil in the area. If the area of farmland was reduced by 10%, output of cassava produced in Eneka Community will decrease by 15.27%. The crude oil spillage parameters, results showed that there is a negative sign in the coefficient of the causes of crude oil spillages (X_3) which was -3.810 and statistically significant at 1% level. This is to say, for every cause of crude oil spillage in the Community which may include pipeline vandalization, pipeline ruptures, drilling of oil wells, oil well sites, and so on, cassava output will reduce

Table 5a: Maximum likelihood estimates for parameters of Cobb-Douglas stochastic frontier production function on cassava production

Variable estimated	Parameters	Crude oil spilled farms		
		Coefficient	Standard Error	t-value
Technical Inefficiency Effects				
Constant	β_0	2.175***	0.580	3.780
Age (Z ₁)	β_1	-0.739	0.450	-1.760
Household size (Z ₂)	β_2	0.822***	0.164	5.012
Education (Z ₃)	β_3	0.460***	0.082	5.610
Farming experience (Z ₄)	β_4	0.755***	0.185	4.081
Gender (Z ₅)	β_5	-1.450***	0.341	-4.252
Marital status (Z ₆)	β_6	0.811***	0.139	5.835

Table 5b: Stochastic Frontier production factors

Constant term	β_0	4.013***	1.011	3.969
Log Lab (X ₁)	β_7	-3.165***	0.326	-9.709
Log farm size (ha) (X ₂)	β_8	-1.527**	0.728	-2.098
Log causes of oil spillage (X ₃)	β_9	-3.810***	0.343	-11.108
Log effect on farmland (X ₄)	β_{10}	-2.911***	0.433	-6.723
Impact on cassava output (X ₅)	β_{11}	-2.255***	0.347	-6.499
Variance ratio	Γ	0.79472	-	-
Lambda	λ	1.96754**	0.38245	5.14457
Sigma U squared	δu^2	0.66172**	0.14089	4.69671

Source: Computer from field survey, 2024 data. NB: *** = 1% significant level, ** = 5% significant level, * = 10% significant level.

by 38.10 %, if these activities were intensively increased by 10%. The coefficient of effects of crude oil spillages on cassava farmland (X₄) was negative as expected (-2.911), and statistically significant at 1%. This means that if there is an increase of crude oil on cassava farmland by 10%, the area cultivated will reduce by 29.11%, hence affecting the cassava output. The impact of crude oil spillage on cassava output (X₅) had a negative coefficient of -2.255 as expected which was significant at 1%. This means that if there is an increase in crude oil spillage by 10%, cassava output will reduce by 22.55%, just like the area of farmland cultivated was decreased by 29%.

The results showed that variables such as household size (Z₂), formal education (Z₃), farming experience (Z₄), gender (Z₅) and marital status (Z₆) were statistically significant at 1% level, while age (Z₁) was statistically significant at 10% level. The coefficient of age (Z₁) was negative [-0.739], meaning if farm labour increases, such as coping with crude oil spillage on farmland replanting and repeating farm activities, the output will reduce by 7.39% if age is increased by 10%. The coefficient of household size (Z₂) was positive (0.822) meaning that if the household size is increased by 10%, output will increase on the crude oil spilled farms by 8.22%. The coefficient of formal education (Z₃) was also positive (0.460), that is, if level of educational input was increased by 10%, the output of the cassava farms under study would increase by 4.60%. Farming experience (Z₄) had a positive coefficient of 0.755, which means that experience in cassava farming and the ability to cope

with oil spillage on the farm could increase output by 7.55% if the farmers' experience is increased by 10%.

Inefficiency factors [Ui]

The coefficient of gender (Z₅) was surprisingly negative (-1.450) which means there could be a severe decrease in cassava output by 14.50% if the current gender balance was established and more females owned cassava farmland by 10%, currently, males dominated in cassava production in the study area. The marital status coefficient (Z₆) was positive (0.811). This means that if more men and women are married, marital status increases by 10%, and the output of cassava farms will increase by 8.11%.

$$U = 2.175 - 0.739Z_1 + 0.822Z_2 + 1.450Z_5 + 0.811Z_6$$

Resource use efficiency

The findings in (Table 6) indicated that the sum of the input coefficients used in cassava production was -6.947 for oil-spilled farms and 5.215 for non-oil-spilled farms. The coefficient of -6.947 suggests that the negative impact of crude oil spillage on the cassava plots resulted in a decrease in production. This means that additional physical inputs were no longer necessary. The production was in the third stage of the production stages, where the effects of physical inputs had been severely affected by the detrimental effects of crude oil spillage on the

Table 6: Elasticity of production inputs used in cassava production in oil-spilled and non-spilled farms.

Resource used	Elasticity of inputs on oil spilled farms	Elasticity of inputs on non-oil spilled farms
Labour	-3.165	1.444
Land (farm size)	-1.527	3.771
Oil spillage	-2.255	--
Return to scale (RTS)	-6.947	5.215

Source: Field Survey, 2024.

cassava farms. However, the results on non-oil spilled farms showed increasing returns to scale of 5.215, indicating that the production was in the first stage of production of cassava. Further increase in inputs will increase production. Therefore, crude oil spillage on cassava farms is detrimental to the resources used in production.

Conclusion and recommendations

The study stated conclusively that crude oil pollution had detrimental and negative effects on the cultivated farmland and the production of cassava crops, leading to a decrease in farm income. It emphasized the importance of an immediate response to oil spills, proactive measures in dealing with oil spillage and improving the security of pipelines to prevent vandalism. Additionally, constant environmental monitoring and evaluation should be encouraged to determine the level of damage.

Conflict of interest

There is no conflict of interest from any of the authors in this work.

REFERENCES

- Abah, G. O., Orisakwe, L., Okoroma, E. O., & Emerhiohi, E. (2020). Deferential effects of oil spillage on cassava farmer's livelihood in Eleme and Ogoni Land Areas of Rivers State, Nigeria. *Middle East Journal of Agriculture, Research*, 9(4), 791-795.
- Ahmadu, J., & Egbodion, J. (2013). Effect of oil spillage on cassava production in Nigeria Delta region of Nigeria. *American Journal of Experimental Agriculture*, 3(4), 914-926.
- Anang, B.T., Stefan, B. & Timo, S. (2016). Agricultural micro credit and technical efficiency: the case of smallholder rice farmers in Northern Ghana. *Journal of Agricultural and Rural Development in the Tropics and Subtropics*, 117,189-202
- Chikaire, J. U., Ani, A. O., Ogueri, E. L., & Orusha, J. O. (2015). Effects of oil spillage (pollution) on agricultural production in Delta Central Agricultural Zone of Delta State Nigeria. *International Journal of Environmental Science*, 4(2), 75-80.
- Essien, O. E., & John, I. A. (2010). Impact of crude oil spillage pollution and chemical remediation on agricultural soil properties and crop growth. *Journal of Applied Science and Environmental Management*, 14(4), 147-154.
- Essifile L.p., & Crentsil C. (2014). Measurement of technical efficiency of small scale fish production in Ghana: a stochastic frontier approach. *Journal of Development and Agricultural Economics*, 6(5), 203-211.
- Mussa, H., Kasnda, E., Jere, W. W. L., & Ng'ong'ola, D. H. (2020). Resource use efficiency in tilapia production in central and southern Malawi. *Aquaculture Economics and Management*, 24(3), 213-231..
- Ifeoma, C. M., Emmanuel, I. M., Jonathan, E. O., & Winnie, O. A. (2019). Causes and terrain of oil spillage in Niger Delta Region of Nigeria: The Analysis of Variance Approach. *International Journal of Energy Economics and Policy*, 9 (2), 283-287.
- Iheke, O. R., Achu, R. N., & Nwaneri, T. C. (2019). Effects of oil spillage on the productivity of farmers in Rivers State, Nigeria. *International Journal of Agriculture and Development Studies*, 4 (1), 23-35.
- Kalu, V.C. (2022). Determining the effects of crude oil spillage on cassava farms in Eneka community in Obio/Akpor Local Government Area of Rivers State , Nigeria. An unpublished M.Sc Dissertation, Department of Agriculture,[Agricultural Economics option] IAUE, Port Harcourt, Nigeria.
- Kalu, V.C., Wilcox, G.I., & Ojimba, T.P. (2024). Socioeconomic characteristics of cassava farmers and impacts of crude oil spillage on farmers livelihood in Eneka Community, Obio/Akpor Local Government Area of Rivers State, Nigeria. *Direct Research Journal of Agriculture and Food Science*. 12(3),45-51.
- Nwachukwu, I., & Ekanem, J. (2016). *Oil exploration environment degradation and sustainable agriculture in the Niger Delta*. Lambhouse: Umuahia, 75-82
- Ojimba, T. P., Akintoala, J., Anyanwu, S. O., & Manilla, H. A. (2014). An economic analysis of crude oil pollution effects on crop farms in Rivers State. *Nigeria Journal of Development and Agricultural Economics*, 6(7), 290-298.
- Ojimba, T. P. (2005). Comparative analysis of crop production in crude oil polluted and non-polluted farmlands in Rivers State, Nigeria. *Journal of Vocational Education and Technology*, 2(1), 113-130.
- Ojimba, T. P. (2011). Economic effects of crude oil spillages on crop farms in Rivers State, Nigeria. *Global Journal of Pure and Applied Sciences*, 17(2), 131-136.
- Ojimba, T. P., & Iyagba, A. G. (2012). Effects of crude oil pollution on horticultural crops in Rivers State, Nigeria. *Global Journal of Science Frontier Research*,12(4), 137-144.
- Ogundari, K. (2006). Determinants of profit efficiency among small-scale rice farmers in Nigeria: A profit function approach. A poster paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12–18.
- Wilcox, G.I., Chiedozie-Ejezie, N.S., & Ojimba T.P. (2024). A comparative analysis of the technical efficiency of artisanal fishermen affected by oil spill and nonoil spill in Bayelsa State. *Direct Research Journal of Management and Strategic Studies*, 5(2), 142-148.