




Assessment of the effects of environmental pollution on farming activities in Ondo State, Nigeria

 **Aminu, Folsasade Oluremi¹⁺**
Ladapo, Hakeem Lanrewaju²

¹Department of Agricultural Extension and Management, School of Agricultural Technology, Yaba College of Technology, Epe Campus, P. M. B. 2011, Yaba, Lagos State, Nigeria.

¹Email: folaajfe02@gmail.com

²Department of Agricultural and Bio-Environmental Engineering, Yaba College of Technology, Epe Campus, P. M. B. 2011, Yaba, Lagos State, Nigeria.

²Email: mrladapo@yahoo.com



(+ Corresponding author)

ABSTRACT

Article History

Received: 27 February 2026

Revised: 6 April 2026

Accepted: 15 April 2026

Published: 23 April 2026

Keywords

Agricultural productivity
Agrochemicals
Environmental pollution
Mitigation strategies
Nigeria
Ondo State
Smallholder farmers.

The study examined the effects of environmental pollution on smallholder farming activities in Ondo State, Nigeria. Using a cross-sectional survey, 120 farmers were sampled with structured questionnaires to collect data on socio-economic characteristics, sources and levels of pollution, perceived impacts on crops and livestock, and mitigation strategies. Descriptive statistics and multiple regression analysis were used for data analysis. Results showed that agrochemical use (81.7%), water pollution from runoff (73.3%), soil erosion and land degradation (61.7%), oil exploration activities (59.2%), and emissions from livestock (56.7%) were the major sources of environmental pollution. The majority (76.7%) of farmers were exposed to some degree of environmental pollution, leading to reduced crop yields, poor soil fertility, water contamination, increased pest resistance, livestock health problems, and higher production costs. Regression analysis indicated that sex, education, household size, farm size, frequency of extension agents' visits, major occupation, off-farm engagement, cooperative membership, access to credit, income, and proximity to pollution sources significantly influenced farmers' exposure to pollution. Farmers adopted mitigation strategies including crop diversification, crop rotation, and soil conservation, though the use of organic methods, water treatment systems, and precision technologies remained low. The study concludes that environmental pollution poses significant economic and health risks to farmers and recommends integrated measures such as sustainable farming practices, farmer education, cooperative engagement, financial support, and enforcement of environmental regulations to mitigate pollution impacts and enhance agricultural productivity in Ondo State.

Contribution/Originality: This study contributes to the existing literature by providing empirical evidence on environmental pollution and smallholder farming in Ondo State. This study uses multiple regression analysis. It is one of the very few studies that have investigated integrated effects, determinants, and mitigation strategies. The paper's primary contribution is that institutional factors significantly shape pollution exposure.

1. INTRODUCTION

Agriculture remains a cornerstone of Nigeria's economy, providing livelihoods for millions of smallholder farmers, ensuring food security, and contributing to rural development (Eleke, Jibril, & Nte, 2019). In Ondo State, smallholder farming dominates the agricultural landscape, producing both staple and cash crops. However, the sector faces increasing challenges from environmental pollution, which threatens the sustainability of agricultural

production. Sources of pollution include excessive use of agrochemicals, industrial emissions, oil exploration, livestock waste, improper disposal of solid and liquid wastes, and soil degradation (Godson-ibeji & Chikaire, 2016; Okojie, Osajiele, & Oboniye, 2019). These pollutants accumulate in soils, water bodies, and the atmosphere, creating serious risks for both crop and livestock production as well as human health (Kornom-Gbaraba, Nabie, Lass, & Ephraim, 2022). Smallholder farmers, who often lack formal education, access to extension services, or modern technologies, are particularly vulnerable to these environmental hazards (Eleke et al., 2019).

Environmental pollution has been linked to declining crop yields, deterioration of soil fertility, contamination of irrigation water, increased pest and livestock diseases, and rising production costs, which collectively reduce household income and threaten rural livelihoods among smallholder farmers (Nwokoro & Chima, 2017). Despite the severity of these challenges, empirical data on the magnitude of environmental pollution, the socio-economic factors influencing farmers' exposure, and the mitigation strategies adopted in the state remain limited. This knowledge gap hinders the design of effective policies and interventions to protect smallholder farmers and promote sustainable agriculture.

Existing studies Ejiba, Onya, and Adams (2016); Eleke et al. (2019); Godson-ibeji and Chikaire (2016); Kornom-Gbaraba et al. (2022); Modu et al. (2025), and Okojie et al. (2019) have documented the negative impacts of environmental pollution on agricultural productivity in other regions of Nigeria and Sub-Saharan Africa. Excessive reliance on chemical fertilizers and pesticides has been shown to disrupt soil nutrient balance, reduce yields, contaminate water resources, and encourage pesticide resistance (Modu et al., 2025). Oil exploration activities release hydrocarbons into soil and water systems, negatively affecting crops and livestock (Udotong, Udouo, & Udotong, 2017) while industrial and domestic wastes further aggravate soil and water pollution, increasing crop disease prevalence and livestock mortality (Eleke et al., 2019; Nriagu, Udofia, Ekong, & Ebuk, 2016). Socio-economic factors such as education, household size, farm size, cooperative membership, and access to credit influence farmers' vulnerability and adaptive capacity (Aminu, Edun, & Ojo, 2025). Farmers with higher education or cooperative support are better able to adopt safer and more sustainable farming practices, while those operating farms close to pollution sources are more vulnerable (Aminu et al., 2025). Mitigation strategies such as crop diversification, soil conservation, organic inputs, and efficient water management have been demonstrated to reduce the adverse effects of pollution on agricultural productivity (Aminu et al., 2025; Food and Agriculture Organization, 2017).

Given these challenges, there is a clear need to understand the integrated effects of environmental pollution on smallholder farming in Ondo State, including the socio-economic determinants of exposure, the major sources and levels of pollution, perceived impacts on crop and livestock production, and the mitigation strategies employed by farmers. Such understanding is critical for developing targeted interventions that enhance agricultural productivity, safeguard natural resources, and improve rural livelihoods. This study seeks to fill this knowledge gap by providing a comprehensive assessment of environmental pollution and its effects on agricultural activities among smallholder farmers in Ondo State, Nigeria.

2. METHODOLOGY

The study was conducted in Ondo State, Nigeria, which was created on February 3, 1976, with Akure as its capital city. The state shares boundaries with Ekiti State to the north, Kogi State to the northeast, Edo State to the east, Delta State to the southeast, and Ogun and Osun States to the southwest. Geographically, it lies between longitudes 4°30' and 6°00' East of the Greenwich Meridian and latitudes 5°45' and 8°15' North of the Equator. Ondo State covers approximately 15,500 square kilometers and had an estimated population of 5,316,600 as of 2022. The state experiences a tropical climate characterized by high temperatures throughout the year, a rainy season from April to October, and a dry season from November to March. These climatic conditions favor extensive agricultural activities. Both arable and perennial crops are cultivated widely, making agriculture a dominant economic activity. In addition to crop farming, residents engage in fishing, logging, trading, and civil service. The state is also endowed

with significant oil resources, contributing about 12% of Nigeria's total oil and gas output, with an estimated reserve of four billion barrels of crude oil. However, oil production activities, alongside intensive agrochemical use and livestock waste generation, have contributed to environmental challenges within the state.

The target population comprised smallholder farmers across selected agricultural communities. A multistage sampling procedure was employed to select 120 respondents. In the first stage, two Local Government Areas (LGAs), characterized by intensive agricultural activity and proximity to potential pollution sources, were purposively selected. In the second stage, two communities were randomly chosen from each LGA. In the final stage, 30 farmers were randomly selected from each community using simple random sampling techniques to ensure representativeness.

Primary data were collected through structured questionnaires designed to obtain information on respondents' socio-economic characteristics, farm attributes, sources and levels of environmental pollution, perceived effects on crop and livestock production, and mitigation strategies adopted. The instrument included both closed-ended and Likert-scale questions, with responses ranging from "Strongly Agree" to "Strongly Disagree." Personal observations of farm conditions, environmental degradation, and proximity to pollution sources were also conducted to validate survey responses.

Data analysis involved both descriptive and inferential statistical techniques. Descriptive statistics such as frequencies, percentages, and means were used to summarize socio-economic characteristics, pollution sources, levels of exposure, and mitigation strategies. Weighted mean scores were applied to analyze perception statements, with a benchmark of 3.0 used as the decision rule for agreement. To determine the factors influencing farmers' exposure to environmental pollution, multiple regression analysis was employed. The model was specified as:

$$Q_i = f(\beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \dots + \beta_{13} X_{13} + e_i) \quad (1)$$

The dependent variable (Q_i) was the level of exposure to pollution.

The X 's are the explanatory variables expressed as:

X_1 = Sex of farmers (1 if male; 0 otherwise), X_2 = Age (Years), X_3 = Education level (Years), X_4 = Household size (Number), X_5 = Farm size (Hectares), X_6 = Farming experience (Years), X_7 = Frequency of extension contact, X_8 = Major occupation (1 if agricultural activities; 0 otherwise), X_9 = Off-farm engagement (1 if yes; 0 otherwise), X_{10} = Membership of cooperative association (1 if yes; 0 otherwise), X_{11} = Access to credit/loan (1 if yes; 0 otherwise), X_{12} = Proximity of farm to industrial activities/pollution sites, X_{13} = Monthly income (₦). β 's = parameters to be estimated, ε = error term.

Four functional forms, linear, exponential, double-log, and semi-log, were tested. The lead equation was chosen based on economic theory (a priori expectations regarding coefficient signs) and statistical criteria, including the coefficient of determination (R^2) and F-statistic. All analyses were conducted using SPSS version 27 to ensure the reliability and robustness of results.

3. RESULTS AND DISCUSSION

The socio-economic characteristics of farmers play a crucial role in determining their exposure, vulnerability, adaptive capacity, and response to environmental pollution. Table 1 presents a summary of selected socio-economic variables of respondents in the study area.

The result shows that 54.2% of the farmers were male, while 45.8% were female, reflecting active participation of both genders in agricultural production. The slight male dominance suggests that men still constitute the majority of farm decision-makers. This supports Ani, Chikaire, Ogueri, and Orusha (2015), who noted that men are often more involved in farm decision-making due to their roles as household heads, while Kornom-Gbaraba et al. (2022) highlighted the indirect but significant impact of pollution on rural women. The majority (55%) of the farmers were above 50 years, with a mean age of 52.38 years, indicating an aging farming population that may possess experience but may be less inclined to adopt innovative pollution-reducing practices.

About 70% had at least secondary education, and 29.2% attained tertiary education, suggesting a relatively high literacy level capable of enhancing the adoption of improved practices, as observed by Edet, Udoe, Isong, and Abiam (2019). Additionally, 73.3% were married, which may provide family labor but also increase household responsibilities. This is consistent with Osarenren and Emokaro (2015), who observed that married farmers are often more mature and better positioned for collaborative decision-making. Over half (55.8%) of households had 6–10 members, with an average of 7 people per household. Larger households provide labor for farming but also increase demand for food and income. Reduced yields due to environmental pollution could therefore significantly impact such families, Godson-ibeji and Chikaire (2016).

Table 1. Summary of selected socio-economic characteristics of the respondents.

| Variables | Frequency | Percentage (%) | Mean |
|------------------------------------|-----------|----------------|------------|
| Sex | | | |
| Male | 65 | 54.2 | |
| Female | 55 | 45.8 | |
| Age (years) | | | |
| 41-50 | 54 | 45.0 | 52.38±6.22 |
| >50 | 66 | 55.0 | |
| Educational Qualification | | | |
| No formal Education | 13 | 10.8 | |
| Primary | 23 | 19.2 | |
| Secondary | 49 | 40.8 | |
| Tertiary | 35 | 29.2 | |
| Marital Status | | | |
| Single | 5 | 4.2 | |
| Married | 88 | 73.3 | |
| Divorced | 7 | 5.8 | |
| Widowed | 20 | 16.7 | |
| Household Size | | | |
| ≤5 | 38 | 31.7 | |
| 6-10 | 67 | 55.8 | 7±2.16 |
| >10 | 15 | 12.5 | |
| Farming Experience | | | |
| ≤10 | 6 | 5.0 | |
| 11-20 | 85 | 70.8 | |
| >20 | 29 | 24.2 | 17.27±4.92 |
| Farm Size | | | |
| ≤1 | 52 | 43.3 | |
| 1.1-3 | 47 | 39.2 | 1.72±1.26 |
| >3 | 21 | 17.5 | |
| Extension Contact | | | |
| No | 68 | 56.7 | |
| Yes | 52 | 43.3 | |
| Farm's Proximity to Pollution Site | | | |
| No | 40 | 33.3 | |
| Yes | 80 | 66.7 | |

Note: $n = 120$.

Source: Field Survey, 2024.

Who cautioned that large families also imply more mouths to feed, which may worsen poverty if environmental pollution undermines production. Most farmers (43.3%) cultivated 1 hectare or less, with an average farm size of 1.72 hectares. Small farms mean limited resources to adopt pollution-mitigating practices. When pollution reduces productivity, these smallholders may struggle to maintain income and food supply.

The majority (70.8%) had 11–20 years of farming experience, with 24.2% having more than 20 years. Experienced farmers are likely aware of long-term soil and water changes caused by pollution. However, they may continue using traditional practices that unintentionally worsen pollution. This aligns with Ani et al. (2015), who noted that

experienced farmers often witness and manage long-term environmental changes affecting production. Over half of the respondents (56.7%) had no contact with agricultural extension services. This limits their access to advice on safe agrochemical use and environmental management, which may contribute to the overuse of fertilizers and pesticides. About 66.7% of farmers reported that their farms were near pollution sources. Being close to contaminated water bodies, industrial discharges, or waste sites increases the risk of soil and crop contamination, which can reduce yields and affect farmer health. This agrees with Ndu-Ogbuji and Mbelegberi (2022), who reported that proximity to polluted areas is a major cause of women's exposure to pollution in Rivers State, Nigeria.

3.1. Major Sources of Environmental Pollution in the Study Area

Table 2 shows the major sources of environmental pollution as reported by the respondents. The findings indicate that agrochemical use is the leading source of environmental pollution, as reported by 81.7% of respondents. This confirms the observation of Modu et al. (2025) that excessive reliance on fertilizers and pesticides contributes significantly to soil and water contamination. Misuse of agrochemicals can disrupt soil nutrient balance, induce pest resistance, and pollute nearby water bodies, thereby reducing crop productivity. Similar concerns were raised by Jibir, Abdu, and Isah (2016) and Okojie et al. (2019), who linked excessive agrochemical application to land degradation and loss of beneficial organisms. Water pollution from runoff and improper waste disposal was identified by 73.3% of farmers, underscoring the role of domestic waste, agricultural residues, and community effluents in environmental degradation. Contaminated water affects irrigation quality and crop growth, consistent with Kodiya et al. (2025), who reported that flooding and excessive irrigation facilitate the movement of chemical residues into rivers and the food chain.

Table 2. Major sources of environmental pollution in the study area.

| *Sources | Frequency | Percentage |
|---|-----------|------------|
| Industrial emissions | 12 | 10.0 |
| Use of agrochemicals | 98 | 81.7 |
| Oil exploration activities | 71 | 59.2 |
| Emission from livestock production | 68 | 56.7 |
| Water pollution from runoff or waste disposal | 88 | 73.3 |
| Soil erosion and land degradation | 74 | 61.7 |
| Excessive irrigation | 31 | 25.8 |
| Air pollution from agricultural activities | 52 | 43.3 |

Note: *Multiple responses.

Source: Field survey data, 2024.

Soil erosion and land degradation were cited by 61.7% of respondents, reflecting the combined effects of deforestation, bush burning, and over-cultivation. This supports Godson-ibeji and Chikaire (2016), who described land degradation as a gradual decline in soil productivity that negatively affects agricultural output. Oil exploration activities were reported by 59.2% of respondents as a pollution source, contributing to soil and water contamination through spills and gas flaring. This finding aligns with Bello and Nwaeke (2023), who noted that oil exploration disrupts farming and fishing livelihoods, and Adeniran, Oladunjoye, and Doro (2023), who documented crude oil contamination of soil and groundwater. Livestock emissions were identified by 56.7% of respondents, highlighting concerns about methane, nitrous oxide, and ammonia emissions, which contribute to environmental degradation and climate change. This agrees with Harisfina and Zornitsa (2018), who identified methane and ammonia as major agricultural pollutants. Air pollution from farming activities, including bush burning and agrochemical spraying, was reported by 43.3% of farmers, consistent with Wei and Wang (2021), who noted that air pollutants impair plant physiological processes and soil quality.

Less frequently reported sources included excessive irrigation (25.8%) and industrial emissions (10%). Although relatively lower in occurrence, these factors can intensify environmental degradation in affected areas, as Makone,

Basweti, and Bunyatta (2021) observed that poorly managed irrigation contributes to soil erosion, salinity, and groundwater pollution. Overall, the results highlight agrochemical use, water contamination, land degradation, and oil-related activities as the dominant environmental challenges in the study area.

3.2. Level of Environmental Pollution Experienced by the Respondents

The results presented in Table 3 indicate that a significant proportion of farmers in Ondo State experience moderate to high levels of environmental pollution. Specifically, 30% of respondents indicated high exposure, 46.7% reported moderate exposure, while only 23.3% experienced low levels of pollution. This implies that about 76.7% of farmers are affected by environmental pollution to varying degrees, with potential consequences for soil fertility, crop performance, and overall farm income.

High pollution exposure is likely linked to factors such as proximity to industrial activities, oil exploration, excessive agrochemical application, and polluted water sources (Ndu-Ogbuji & Mbelegberi, 2022). Moderate exposure suggests that although the immediate effects on productivity may not be severe, there remains a risk of cumulative long-term impacts if appropriate control measures are not adopted. The relatively smaller proportion reporting low exposure may reflect better environmental practices, reduced chemical usage, or greater distance from pollution sources. These findings align with Mirzabaev, Strokov, and Krasilnikov (2023), who noted that environmental stress from chemical inputs, land degradation, and water contamination adversely affects agricultural productivity and rural livelihoods.

Table 3. Level of environmental pollution experienced.

| Level | Frequency | Percentage |
|----------|-----------|------------|
| High | 36 | 30.0 |
| Moderate | 56 | 46.7 |
| Low | 28 | 23.3 |
| Total | 120 | 100.0 |

Source: Field survey data, 2024.

3.3. Perceived Effect of Environmental Pollution on Farming Activities

The results of the 5-point Likert scale assessing farmers' perceptions of the effects of environmental pollution on farming activities are presented in Table 4. The findings show a high level of awareness among farmers in Ondo State regarding the adverse impacts of pollution on agriculture. The statement "Agricultural activities are vulnerable to environmental pollution in my locality" recorded the highest mean score ($\bar{x} = 4.73$), indicating a strong consensus that pollution poses a serious threat to farming. Crop production was notably affected, with high mean scores for reduced crop yield ($\bar{x} = 4.07$), soil contamination resulting in poor fertility ($\bar{x} = 4.10$), and polluted water contributing to crop diseases ($\bar{x} = 4.11$). Farmers also reported changes in soil texture and color ($\bar{x} = 3.67$) and a decline in the availability of clean irrigation water ($\bar{x} = 4.30$). These responses suggest that environmental pollution undermines both production inputs (soil and water quality) and outputs (crop performance and yield), in line with the findings of Godson-ibeji and Chikaire (2016).

Beyond crop production, livestock and pest-related challenges were also evident. Respondents indicated increased pest resistance due to pesticide use ($\bar{x} = 4.10$), deterioration in livestock health ($\bar{x} = 3.92$), livestock diseases from polluted water ($\bar{x} = 4.20$), and reduced livestock productivity from contaminated feed ($\bar{x} = 3.66$). These findings demonstrate that pollution affects both crop and animal production systems, thereby threatening household food security and income. This aligns with Osuagwu and Olaifa (2018), who reported that environmental pollution, including oil spills, leads to reduced crop yields and fish mortality. Economic consequences were also significant. Farmers strongly agreed that pollution increases production costs ($\bar{x} = 4.61$) and reduces household income due to declining productivity ($\bar{x} = 4.33$). This is consistent with Ejiba et al. (2016), who found that oil spillage and gas flaring

have severely affected the livelihoods of farming and fishing communities, increasing household vulnerability and undermining long-term sustainability.

Conversely, lower mean scores were recorded for farm abandonment ($\bar{x} = 2.53$) and reliance on external assistance ($\bar{x} = 2.86$), indicating that most farmers continue their agricultural activities despite environmental challenges. This reflects resilience and the economic necessity of sustaining farming operations. Additionally, respondents acknowledged adverse health effects associated with pollution exposure ($\bar{x} = 3.80$), reinforcing the broader implications for rural wellbeing. This observation is supported by Ejiba et al. (2016) and Aminu, Ladapo, and Ojo (2020), who reported that pollution and improper agrochemical use negatively affect both livelihoods and health outcomes in rural communities.

Table 4. Perceived effects of environmental pollution on agricultural activities.

| Statements | Mean | SD |
|---|------|-------|
| Agricultural activities are vulnerable to environmental pollution in my locality | 4.73 | 0.374 |
| Environmental pollution has significantly reduced crop yield in my farm | 4.07 | 0.361 |
| Polluted water sources have negatively impacted irrigation practices | 3.83 | 0.301 |
| Soil contamination due to pollution has led to poor soil fertility | 4.10 | 0.460 |
| I have observed changes in soil texture and color due to environmental pollution | 3.67 | 0.501 |
| I have noticed a decline in the availability of clean water for farming due to pollution | 4.30 | 0.502 |
| Polluted water sources have contributed to crop diseases in my farm | 4.11 | 0.498 |
| Environmental pollution has led to a decline in the variety of crops I can grow | 3.85 | 0.460 |
| Environmental pollution has affected my ability to store and preserve agricultural produce | 3.55 | 0.484 |
| Environmental pollution has increased pest resistance due to pesticide use | 4.10 | 0.444 |
| Livestock health has deteriorated due to environmental pollution | 3.92 | 0.460 |
| Polluted water sources have caused diseases in livestock | 4.20 | 0.402 |
| There has been a decrease in livestock production due to contaminated feed | 3.66 | 0.444 |
| Environmental pollution has led to increased costs of agricultural production | 4.61 | 0.473 |
| There has been a significant decrease in household income due to reduced agricultural productivity | 4.33 | 0.498 |
| Environmental pollution has forced farmers to abandon their farms. | 2.53 | 0.498 |
| Environmental pollution has made me more reliant on external assistance (e.g., government support, aid) | 2.86 | 0.498 |
| Environmental pollution has adversely affected my health | 3.80 | 0.478 |

Note: SD=Standard Deviation

Source: Field survey data, 2024.

3.4. Determinants of Farmers' Exposure to Environmental Pollution in Ondo State

The results of the multiple regression analysis examining the determinants of farmers' exposure to environmental pollution are presented in Table 5. Among the functional forms tested, the linear model was selected as the main equation based on its relatively high coefficient of determination, the number of statistically significant variables, and a significant F-statistic.

Table 5. Determinants of farmers' exposure to environmental pollution in Ondo state.

| Variables | Coefficient | T-ratio | Sig. |
|---|-------------|---------|-------|
| (Constant) | 2.398 | 6.958 | 0.001 |
| Sex | 0.242** | 2.069 | 0.041 |
| Age | -0.002 | -0.233 | 0.816 |
| Education | -0.249*** | -3.396 | 0.001 |
| Household size | -0.026*** | -2.158 | 0.033 |
| Farm size | 0.025* | 1.944 | 0.055 |
| Farming experience | -0.001 | 0.103 | 0.919 |
| Frequency of extension agents' visit | 0.175** | 2.455 | 0.016 |
| Agricultural activities as a major occupation | 0.979*** | 4.788 | 0.001 |
| Off-farm engagement | 0.131* | 1.910 | 0.059 |
| Cooperative association membership | -0.492*** | -4.061 | 0.001 |

| Variables | Coefficient | T-ratio | Sig. |
|--|-------------|---------|-------|
| Access to a loan | -0.884*** | -6.446 | 0.001 |
| Farm located close to a pollution site | 0.183*** | 3.250 | 0.002 |
| Income | -0.000** | -2.071 | 0.041 |
| R | 0.783 | | |
| R ² | 0.747 | | |
| Adj. R ² | 0.688 | | |
| F | 19.685 | | |

Note: ***, ** and * indicate significance at 1%, 5% and 10% respectively.

Source: Field survey data, 2024.

The model exhibited strong explanatory power ($R^2 = 0.747$), indicating that 74.7% of the variation in pollution exposure is explained by the included explanatory variables. The F-statistic was significant at the 1% level, confirming the overall fitness and reliability of the model.

The results reveal that the sex of the farmer ($p < 0.05$) had a positive and significant relationship with pollution exposure, implying that male farmers are more exposed than their female counterparts. This may be attributed to men's greater involvement in tasks such as land clearing and agrochemical application, which increase direct contact with pollutants (Ani et al., 2015). Education ($p < 0.01$) showed a negative and significant relationship with exposure, indicating that higher educational attainment reduces vulnerability to environmental pollution. Educated farmers are more likely to apply agrochemicals appropriately and adopt environmentally sustainable practices. This agrees with the findings of Zhang, Fu, Wang, and Zhang (2019), who reported that literate farmers are more likely to adopt modern technologies. Household size ($p < 0.05$) was negatively and significantly related to pollution exposure, suggesting that larger households may distribute farm tasks among members, thereby reducing repeated individual exposure.

Farm size ($p < 0.10$) had a positive relationship with exposure, implying that farmers operating larger holdings are more likely to experience higher pollution levels, possibly due to more intensive input use and production practices. Frequency of extension visits ($p < 0.05$) was positively and significantly associated with exposure. This suggests that farmers with more frequent extension contact may be more aware of environmental risks and better able to recognize and report pollution issues. It may also reflect the concentration of extension activities in areas already experiencing environmental challenges. Engagement in agriculture as the major occupation ($p < 0.01$) had a strong, positive, significant effect, indicating that full-time farmers face higher exposure due to continuous involvement in farming operations. Notably, off-farm engagement ($p < 0.10$) was also positively significant, suggesting that farmers who are involved in off-farm activities may still experience substantial exposure. This may reflect continued participation in farming alongside other income-generating activities or involvement in off-farm work located in environmentally vulnerable areas.

Cooperative membership ($p < 0.01$) exhibited a negative and significant relationship with pollution exposure, indicating that membership in farmer groups reduces vulnerability through access to information, training, and improved farming practices. This is consistent with the findings of Yifru and Miheretu (2022) that membership in a local organization assists a person in obtaining information on improved farming practices. Access to loans ($p < 0.01$) similarly had a negative and significant effect, implying that financial resources enable farmers to invest in pollution-reducing technologies and safer production methods. Farm proximity to pollution sources ($p < 0.01$) was positively and significantly related to exposure, confirming that location near industrial sites, oil exploration areas, or waste disposal points increases environmental risk. This is consistent with the findings of Ndu-Ogbuji and Mbelegberi (2022), which agree that proximity to polluted areas is a major cause of women's exposure to pollution in Rivers State, Nigeria.

Finally, income ($p < 0.05$) showed a negative and significant relationship with exposure, suggesting that higher-income farmers are better positioned to adopt mitigation measures and reduce their vulnerability to environmental pollution.

3.5. Strategies Adopted to Mitigate the Effects of Environmental Pollution

Results in Table 6 indicate that farmers in Ondo State employ several strategies to lessen the effects of environmental pollution on their farming activities. These include:

Crop and soil management: A substantial proportion of farmers practice crop diversification (65%) and modify crop selection or rotation patterns (48.3%) as adaptive measures. These approaches enhance soil fertility, lower pest and disease pressure, and sustain productivity in polluted environments. Crop rotation, in particular, can reduce dependence on chemical inputs, thereby limiting further soil and water contamination. Additionally, 55% of respondents adopted soil conservation techniques such as mulching, contour farming, and cover cropping to control erosion and protect fertile topsoil, which is often degraded by pollution.

Agrochemical and Pest Management: Despite environmental concerns, 60% of farmers reported continued use of agrochemicals. While this may support short-term yield improvements, excessive or improper use can intensify environmental degradation. However, some farmers are gradually shifting toward safer alternatives, with 27.5% using organic or bio-pesticides and 18.3% adopting alternative pest control methods.

Water and Nutrient Management: Efficient water and nutrient management practices were adopted by 26.7% of respondents. Proper irrigation and fertilizer application can reduce nutrient leaching and limit contamination of surrounding water bodies. Only 10% installed water purification systems, suggesting financial and technical constraints in implementing such measures.

Education and Extension Support: Participation in extension programs specifically focused on pollution management was relatively low (14.2%), indicating limited access to targeted training. Expanding extension services could enhance awareness and encourage wider adoption of sustainable practices.

Technology Adoption: The use of precision agricultural technologies was minimal (1.7%), reflecting limited access to modern innovations that can optimize input use and minimize environmental harm. This underscores the need for increased investment and policy support to promote advanced, environmentally sustainable farming technologies.

Table 6. Strategies adopted to mitigate the effects of environmental pollution.

| *Strategies | Frequency | Percentage |
|--|-----------|------------|
| Changed crop selection or rotation pattern | 58 | 48.3 |
| Use of agrochemicals | 72 | 60.0 |
| Implemented soil conservation measures | 66 | 55.0 |
| Efficient water and nutrient management | 32 | 26.7 |
| Adopted organic farming methods | 16 | 13.3 |
| Use of alternative pest control methods | 22 | 18.3 |
| Use precision agricultural technologies | 2 | 1.7 |
| Use of organic or bio-pesticides | 33 | 27.5 |
| Participation in agricultural extension programs on pollution management | 17 | 14.2 |
| Implementation of crop diversification | 78 | 65.0 |
| Installation of water purification systems | 12 | 10.0 |

Note: *Multiple responses

Source: Field survey data, 2024.

4. CONCLUSION

The study revealed that environmental pollution is a significant challenge for smallholder farmers in Ondo State, affecting both crop and livestock production. Major sources of pollution include excessive agrochemical use, water contamination from runoff and waste disposal, oil exploration activities, and soil degradation.

The majority of farmers experience moderate to high levels of pollution, which has led to reduced crop yields, poor soil fertility, increased pest resistance, livestock health problems, and higher production costs, ultimately impacting household income and livelihoods. Socio-economic and farm-related factors such as education, cooperative

membership, access to credit, farm size, frequency of farm visits, and proximity to pollution sources significantly influence farmers' exposure to environmental pollution.

Overall, the study concludes that environmental pollution poses both economic and health risks to smallholder farmers, highlighting the need for integrated interventions to protect farmers' livelihoods and promote sustainable agriculture.

4.1. Recommendations

Based on the findings, the study recommends the following for policymakers, farmers, and stakeholders.

1. Regular training programs on safe agrochemical use, pollution management, and sustainable farming techniques should be provided to farmers, especially those with low educational levels.
2. Participation in cooperatives should be encouraged, as it reduces exposure to pollution by facilitating knowledge sharing, pooled resources, and safer farming practices.
3. Government and microfinance institutions should provide loans or grants to enable farmers to adopt safer farming technologies, water treatment systems, and pollution mitigation strategies.
4. Authorities (government and other relevant agencies) should enforce environmental regulations, ensure proper waste management, and implement zoning policies that separate agricultural lands from high-pollution areas.
5. Farmers should be supported by the government and stakeholders to adopt precision agriculture, efficient water and nutrient management, agroforestry, alternative pest control methods, organic fertilizers, bio-pesticides, crop rotation, and soil conservation techniques to minimize environmental impacts.

Funding: This study received no specific financial support.

Institutional Review Board Statement: The study involved minimal risk and followed ethical guidelines for social science fieldwork. Formal approval from an Institutional Review Board was not required under the policies of Yaba College of Technology, School of Agricultural Technology, Lagos State, Nigeria. Informed verbal consent was obtained from all participants, and all data were anonymized to protect participant confidentiality.

Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.

Competing Interests: The authors declare that they have no competing interests.

Authors' Contributions: Both authors contributed equally to the conception and design of the study. Both authors have read and agreed to the published version of the manuscript.

REFERENCES

- Adeniran, M. A., Oladunjoye, M. A., & Doro, K. O. (2023). Soil and groundwater contamination by crude oil spillage: A review and implications for remediation projects in Nigeria. *Frontiers in Environmental Science*, 11, 1137496. <https://doi.org/10.3389/fenvs.2023.1137496>
- Aminu, F. O., Ladapo, H. L., & Ojo, O. O. (2020). Pesticide use and health hazards among cocoa farmers: Evidence from Ondo and Kwara States of Nigeria. *Nigerian Agricultural Journal*, 51(2), 263-273.
- Aminu, F. O., Edun, T. A., & Ojo, O. O. (2025). Effects of environmental pollution on agricultural production activities in the Niger-Delta region of Nigeria. In, *Environmental stress and smart agriculture: Pollution, AI extension, and plant health*. In (pp. 1-28). Nigeria: Halic Academic Publishers.
- Ani, A. O., Chikaire, J. U., Ogueri, E. I., & 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 Sciences*, 4(2), 75-80.
- Bello, A. T., & Nwaeke, T. (2023). Impacts of oil exploration (oil and gas conflicts; Niger Delta as a case study). *Journal of Geoscience and Environment Protection*, 11(3), 189-200. <https://doi.org/10.4236/gep.2023.113013>

- Edet, E. O., Udofe, P. O., Isong, I. A., & Abiam, N. E. (2019). Economics of environmental pollution on cassava-based farmers' health and production efficiency within Lafarge cement concession area in Mfamosing, Cross River State, Nigeria. *World News of Natural Sciences*, 23, 182-199.
- Ejiba, I. V., Onya, S. C., & Adams, O. K. (2016). Impact of oil pollution on livelihood: Evidence from the Niger Delta Region of Nigeria. *Journal of Scientific Research and Reports*, 12(5), 1-12. <https://doi.org/10.9734/JSRR/2016/26633>
- Eleke, P. N., Jibril, M., & Nte, J. M. (2019). A review of the effect of crude oil exploration on agriculture: A case study of the Niger Delta region. *Journal of Agricultural Economics, Environment and Social Sciences*, 5(1 and 2), 87-98.
- Food and Agriculture Organization. (2017). *The future of food and agriculture: Trends and challenges*. Rome: FAO.
- Godson-ibeji, C. C., & Chikaire, J. U. (2016). Consequences of environmental pollution on agricultural productivity in developing countries: A case of Nigeria. *International Journal of Agricultural and Food Research*, 5(3), 1-12.
- Harisfina, H. B., & Zornitsa, S. (2018). *Impact of agriculture on oil pollution*. Paper presented at the International Conference on Innovations in Science and Education, March 21-23, 2018, Prague, Czech Republic.
- Jibir, A., Abdu, M., & Isah, A. (2016). Environmental and sustainable agricultural development in Nigeria: Matters arising and the way forward. *Indian Journal of Sustainable Development*, 2(2), 1-6.
- Kodiya, M. A., Modu, M. A., Ishaq, K., Yusuf, Z., Wakili, A. Z., Dayyabu, N., . . . Babangida, M. U. (2025). Environmental pollution in Nigeria: Unlocking integrated strategies for environmental sustainability. *African Journal of Environmental Sciences and Renewable Energy*, 18(1), 30-50. <https://doi.org/10.62154/ajesre.2025.018.010588>
- Kornom-Gbaraba, M. E., Nabie, V. J., Lass, R., & Ephraim, A. T. (2022). Effect of environmental pollution on rural women in the Niger Delta. *International Journal of Environment and Pollution Research*, 10(1), 1-19.
- Makone, S. M., Basweti, E. A., & Bunyatta, D. K. (2021). Effects of irrigation systems on farming practices: Evidence from Oluch-Kimira Scheme, Homa Bay County, Kenya. *Asian Journal of Advanced Research and Reports*, 15(1), 26-35. <https://doi.org/10.9734/ajarr/2021/v15i130355>
- Mirzabaev, A., Stokov, A., & Krasilnikov, P. (2023). The impact of land degradation on agricultural profits and implications for poverty reduction in Central Asia. *Land Use Policy*, 126, 106530. <https://doi.org/10.1016/j.landusepol.2022.106530>
- Modu, M. A., Kodiya, M. A., Babangida, M. U., Kabara, A. D., Ishaq, K., Ngoshe, H. S., & Maiva, I. M. (2025). Examining the pollution risks of agrochemicals and paths to environmental sustainability: A systematic review. *Journal of Agricultural Economics, Environment and Social Sciences*, 11(1), 238-255. <https://doi.org/10.56160/jaeess/2025/11/1/020>
- Ndu-Ogbuji, C. J., & Mbelegberi, K. R. (2022). Environmental pollution and women vulnerability in Rivers State: The way forward. *European Journal of Humanities and Educational Advancements*, 3(6), 40-47.
- Nriagu, J., Udofia, E. A., Ekong, I., & Ebuk, G. (2016). Health risks associated with oil pollution in the Niger Delta, Nigeria. *International Journal of Environmental Research and Public Health*, 13(3), 346. <https://doi.org/10.3390/ijerph13030346>
- Nwokoro, C. V., & Chima, F. O. (2017). Impact of environmental degradation on agricultural production and poverty in rural Nigeria. *American International Journal of Contemporary Research*, 7(2), 6-14.
- Okojie, O. M., Osajiele, M. A., & Oboniye, J. A. (2019). Impact of agricultural pollution on the economic environment of Nigeria: The way out. *Journal of Agricultural Science and Practice*, 4(4), 134-138. <https://doi.org/10.31248/JASP2019.159>
- Osarenren, C. O., & Emokaro, C. O. (2015). Profitability of cocoa production under different management systems in Edo State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 11(1), 38-43.
- Osuagwu, E. S., & Olaifa, E. (2018). Effects of oil spills on fish production in the Niger Delta. *PLoS One*, 13(10), e0205114. <https://doi.org/10.1371/journal.pone.0205114>
- Udotong, J. I., Udoudo, U., & Udotong, I. (2017). Effects of oil and gas exploration and production activities on production and management of seafood in Akwa Ibom State, Nigeria. *Journal of Environmental Chemistry and Ecotoxicology*, 9(3), 20-42.
- Wei, W., & Wang, Z. (2021). Impact of industrial air pollution on agricultural production. *Atmosphere*, 12(5), 639. <https://doi.org/10.3390/atmos12050639>

- Yifru, G. S., & Miheretu, B. A. (2022). Farmers' adoption of soil and water conservation practices: The case of lege-lafto watershed, Dessie Zuria District, South Wollo, Ethiopia. *PLoS One*, 17(4), e0265071. <https://doi.org/10.1371/journal.pone.0265071>
- Zhang, B., Fu, Z., Wang, J., & Zhang, L. (2019). Farmers' adoption of water-saving irrigation technology alleviates water scarcity in metropolis suburbs: A case study of Beijing, China. *Agricultural Water Management*, 212, 349-357. <https://doi.org/10.1016/j.agwat.2018.09.021>

Views and opinions expressed in this article are the views and opinions of the author(s), International Journal of Sustainable Agricultural Research shall not be responsible or answerable for any loss, damage or liability etc. caused in relation to/arising out of the use of the content.