

ASSESSMENT OF ENVIRONMENTAL MANAGEMENT POLICIES AND POLLUTION CONTROL STRATEGIES IN DEVELOPING ECONOMIES

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ABSTRACT

Environmental pollution constrains sustainable development in developing economies, particularly in Sub-Saharan Africa, where rapid urbanization, industrialization, population growth, and weak institutional capacity strain environmental resources. This study assesses the effectiveness of environmental management policies and pollution control strategies implemented by governments and industries in Nigeria and selected Sub-Saharan African countries, covering air, water, and land pollution, waste management, industrial environmental management, and circular economy initiatives. A convergent mixed-methods design combined a systematic review under the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework (29 sources published 2010–2026, drawn from seven databases and reports of major international organizations) with a questionnaire survey of 286 stakeholders in Anambra, Lagos, and Rivers States, Nigeria, analysed with mean scores, standard deviations, percentages, and the Kruskal–Wallis test. The review shows substantial progress in policy and regulatory frameworks but constrained implementation owing to inadequate funding, weak enforcement, insufficient monitoring infrastructure, institutional fragmentation, and technological limitations. Respondents rated all five programmes (mean scores 3.17–3.33) and air, water, and land pollution control (3.13–3.27) as moderately effective, giving an overall Environmental Performance Index (EPI) of 3.22, and ranked industrial activities as the leading pollution source; environmental officers rated programmes significantly more favourably than community residents. The study proposes an Environmental Governance Effectiveness Framework (EGEF) built on policy strength, institutional capacity, technological innovation, stakeholder participation, and continuous evaluation, and concludes that sustainable environmental management requires integrated governance, stronger enforcement, greater investment, cleaner production, and wider adoption of circular economy principles.

Keywords: Environmental Management, Environmental Governance, Pollution Control, Air Pollution, Water Pollution, Land Pollution, Circular Economy

1.0 INTRODUCTION

Environmental pollution is among the most significant global challenges of the twenty-first century (Intergovernmental Panel on Climate Change [IPCC], 2023; Steffen *et al.*, 2015; United Nations Environment Programme [UNEP], 2021). Industrialization, urbanization, population growth, agricultural intensification, and energy consumption have raised living standards but also generated environmental pressures that threaten ecosystem stability, human health, and sustainable development (Dasgupta, 2021; United Nations Development Programme [UNDP], 2022). Pollution contributes substantially to disease burden, premature

mortality, and economic loss (UNEP, 2021; World Health Organization [WHO], 2021). The Lancet Commission on pollution and health attributed about nine million premature deaths in 2015 to pollution, most of them in low- and middle-income countries (Landrigan *et al.*, 2018), and its update found that this toll had not declined (Fuller *et al.*, 2022).

Developing economies are especially exposed because growth often occurs amid inadequate infrastructure, weak environmental institutions, limited finance, and rapid urbanization (Guerrero *et al.*, 2013; Ferronato & Torretta, 2019). Sub-Saharan Africa is among the fastest-growing regions in population and urban expansion, which raises demand for housing, transport, energy, water, industrial production, and waste services and increases municipal solid waste, transport emissions, and industrial pollution (African Development Bank [AfDB], 2022; Amegah & Agyei-Mensah, 2017; Kaza *et al.*, 2018), while inadequate wastewater treatment, waste disposal, and monitoring infrastructure compound the problem (Onu *et al.*, 2023).

Nigeria is Africa's most populous country and one of its largest economies, with substantial petroleum, gas, agricultural, forest, and water resources that are under pressure from industrial development, urban expansion, oil exploration, and population growth. Air pollution arises from transportation, industry, gas flaring, biomass combustion, and electricity generation (Amegah & Agyei-Mensah, 2017); water pollution from industrial discharges, oil spills, agricultural runoff, and inadequate wastewater treatment (Ighalo *et al.*, 2021); and land pollution from poor waste management, industrial contamination, mining, and unsustainable land use (Sam *et al.*, 2016). The consequences extend to health, productivity, and food and water security: air pollution contributes to respiratory and cardiovascular disease and premature mortality (WHO, 2021) and imposes large economic and human capital costs in Africa (Fisher *et al.*, 2021), water pollution increases waterborne disease, and land pollution reduces agricultural productivity and ecosystem services.

Governments have responded with environmental management policies and pollution control strategies, and environmental management has evolved from reactive control towards sustainability-oriented frameworks that emphasize prevention, resource efficiency, governance, and stakeholder participation (Awewomom *et al.*, 2024). In Nigeria and many other Sub-Saharan African countries, governance systems have expanded since the 1980s through environmental ministries, regulatory agencies such as the National Environmental Standards and Regulations Enforcement Agency (NESREA), environmental impact assessment (EIA) requirements (Ogunba, 2004), pollution standards, and monitoring programmes, supported by international agreements.

Despite these advances, degradation remains widespread, and studies report persistent problems of policy implementation, institutional capacity, enforcement, financing, technology, and governance effectiveness (Ogunbode, 2026; Ogunbode *et al.*, 2026; Okimiji *et al.*, 2026; Olagunju *et al.*, 2026). Outcomes therefore depend not only on regulations but also on implementation capacity, stakeholder engagement, institutional effectiveness, and technological capability. Through a systematic review of the evidence on policy frameworks, institutional arrangements, implementation, and outcomes, complemented by a stakeholder questionnaire survey, this study critically assesses environmental management policies and pollution control strategies in developing economies, focusing on governmental and industrial programmes in Nigeria and selected Sub-Saharan African countries, and offers evidence-based recommendations for strengthening environmental governance.

Nigeria presents a particularly important case study because it is Africa's most populous country and one of its largest economies. The country possesses significant natural resources, including petroleum, natural gas, agricultural land, forests, and water resources. However, these resources have experienced considerable environmental pressures arising from industrial development, urban expansion, oil exploration activities, and population growth.

Environmental pollution in Nigeria occurs in multiple forms. Air pollution is generated by transportation activities, industrial operations, gas flaring, biomass combustion, and electricity generation (Amegah & Agyei-Mensah, 2017). Water pollution arises from industrial discharges, oil spills, agricultural runoff, and inadequate wastewater treatment (Ighalo *et al.*, 2021). Land pollution results from poor waste management practices, industrial contamination, mining activities, and unsustainable land-use practices (Sam *et al.*, 2016). The environmental consequences of pollution extend beyond ecological impacts. Environmental degradation affects human health, economic productivity, food security, water security, and social welfare. Air pollution contributes to respiratory illnesses, cardiovascular diseases, and premature mortality (WHO, 2021), and in Africa it also imposes large economic and human capital costs (Fisher *et al.*, 2021). Water pollution threatens drinking water supplies and increases the prevalence of waterborne diseases. Land pollution reduces agricultural productivity and degrades ecosystem services essential for sustainable development.

Recognition of these challenges has led governments worldwide to develop environmental management policies and pollution control strategies aimed at protecting environmental quality and promoting sustainable development. Environmental management has evolved significantly over the past several decades, transitioning from reactive pollution control approaches toward more comprehensive sustainability-oriented frameworks that emphasize pollution prevention, resource efficiency, environmental governance, and stakeholder participation (Awewomom *et al.*, 2024).

In Nigeria and many other Sub-Saharan African countries, environmental governance systems have expanded considerably since the 1980s. Governments have established environmental ministries, regulatory agencies such as Nigeria's National Environmental Standards and Regulations Enforcement Agency (NESREA), environmental impact assessment (EIA) requirements (Ogunba, 2004), pollution standards, and environmental monitoring programmes. International agreements and sustainable development initiatives have further encouraged environmental policy development and institutional strengthening.

Despite these advances, environmental degradation remains widespread. Numerous studies have reported persistent challenges related to policy implementation, institutional capacity, regulatory enforcement, financial constraints, technological limitations, and governance effectiveness (Ogunbode, 2026; Ogunbode *et al.*, 2026; Okimiji *et al.*, 2026; Olagunju *et al.*, 2026). Consequently, questions remain regarding the actual effectiveness of existing environmental management policies and pollution control strategies in achieving environmental sustainability objectives.

The persistence of environmental degradation despite extensive policy interventions suggests that environmental governance outcomes depend not only on the existence of regulations but also on implementation capacity, stakeholder engagement, institutional effectiveness, and technological capability. Understanding these relationships is essential for improving environmental management systems and designing more effective pollution control strategies.

This study therefore seeks to critically assess environmental management policies and pollution control strategies in developing economies, focusing specifically on governmental and industrial programmes implemented in Nigeria and selected Sub-Saharan African countries. Through a systematic review of the evidence on policy frameworks, institutional arrangements, implementation mechanisms, and environmental outcomes, complemented by a questionnaire survey of stakeholders, the study aims to provide evidence-based recommendations for strengthening environmental governance and promoting sustainable development.

1.1 Conceptual Framework

The framework explains how governance mechanisms influence pollution control effectiveness and environmental quality. It assumes that sustainability depends on five interacting components: (i)

environmental policies and regulations, such as EIA requirements and air quality, water quality, and waste management standards, which set legal responsibilities; (ii) institutional capacity, reflected in the expertise, staff, laboratories, monitoring infrastructure, and finance available to regulators; (iii) industrial environmental performance, indicated by compliance, environmental management systems (EMS), cleaner production technologies, and environmental reporting; (iv) stakeholder participation by communities, civil society, academia, and advocacy groups, which improves transparency and accountability; and (v) environmental monitoring systems, which supply the air, water, soil, and waste data needed for compliance assessment and policy evaluation. Together these are expected to shape the dependent variable, environmental sustainability outcomes: improved air and water quality, reduced land pollution, healthier ecosystems, and public health benefits. The framework is underpinned by Institutional Theory (DiMaggio & Powell, 1983), under which organizational behaviour is shaped by regulatory, normative, and social pressures; strong regulatory institutions should therefore improve compliance and weak institutions encourage violations, an emphasis particularly relevant in developing economies, where institutional effectiveness varies considerably.

2.0 MATERIALS AND METHODS

2.1 Research Design

This study adopted a convergent mixed-methods design (Creswell & Plano Clark, 2018) with two strands addressing the same aim. The first is a systematic literature review (SLR) of published evidence on the effectiveness of environmental management policies and pollution control strategies implemented by governments and industries in Nigeria and selected Sub-Saharan African countries. The second is a cross-sectional questionnaire survey of stakeholders' perceptions of the effectiveness of these programmes. The strands were conducted in parallel, analysed separately, and integrated in the Discussion (Section 3.9), where survey ratings are compared with patterns in the review evidence. Sections 2.2 to 2.7 describe the review strand, Section 2.8 the survey strand, and Section 2.9 the statistical techniques.

The systematic approach was chosen because, unlike narrative reviews, it follows a predefined protocol that is transparent and reproducible and minimizes selection bias. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page *et al.*, 2021), which standardize the identification, screening, eligibility assessment, and inclusion of studies.

2.2 Scope of the Review

The review covered Nigeria and selected Sub-Saharan African countries, which face significant pollution pressures from rapid urbanization, industrialization, population growth, inadequate infrastructure, and weak environmental governance. It examined policies, programmes, and interventions by governments, industries, international organizations, and environmental agencies in eight areas: air quality management, water resource protection, wastewater management, municipal solid waste management, industrial pollution control, land degradation prevention, circular economy initiatives, and environmental governance and regulatory systems. Publications from 2010 to 2026 were considered, with emphasis on 2015–2026 so that findings reflect current practice.

2.3 Search Strategy and Information Sources

Seven electronic sources were searched: Scopus, Web of Science, ScienceDirect, SpringerLink, Wiley Online Library, Taylor & Francis Online, and Google Scholar. Additional evidence came from reports of the United Nations Environment Programme (UNEP), the World Health Organization (WHO), the World Bank, and the

African Development Bank (AfDB). Search strings combined three concept blocks with Boolean operators and were adapted to each database's syntax: (1) environmental policy and governance ("environmental polic" OR "environmental governance" OR "environmental regulation" OR "environmental management" OR enforcement); (2) pollution control ("pollution control" OR "air pollution" OR "water pollution" OR "land pollution" OR "waste management" OR wastewater OR "industrial emission" OR "circular economy"); and (3) geographic context (Nigeria OR "Sub-Saharan Africa" OR "developing countr" OR "developing econom*"). The blocks were combined with AND and applied to title, abstract, and keywords, limited to English-language publications from 2010 to 2026 (in Scopus: TITLE-ABS-KEY(block 1 AND block 2 AND block 3) AND PUBYEAR > 2009 AND PUBYEAR < 2027 AND LANGUAGE(english)). Asterisks denote truncation.

2.4 Eligibility Criteria

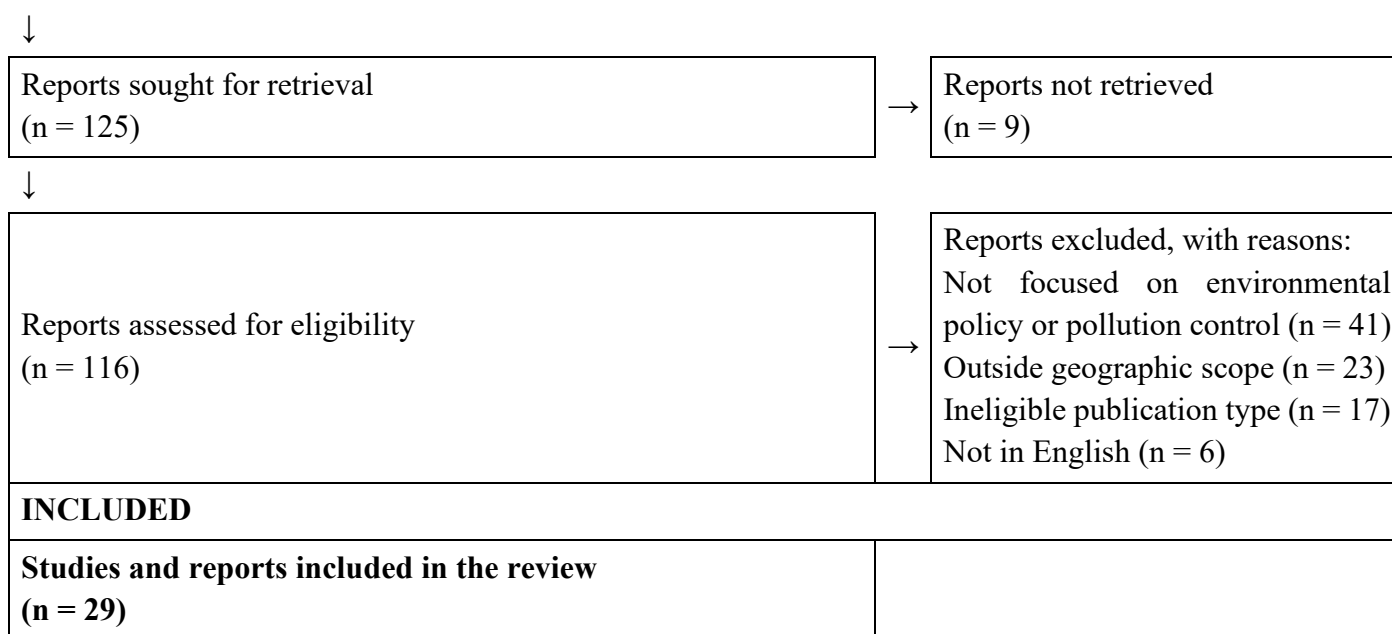
Records were screened against predefined criteria. Included were peer-reviewed journal articles (empirical studies and reviews) and reports of recognized international organizations, published in English between 2010 and 2026 with full text accessible, that addressed environmental management policies, regulation, governance, or pollution control strategies for air, water, or land pollution, waste, industrial pollution, or the circular economy in Nigeria, Sub-Saharan Africa, or other developing economies where findings are relevant to the region. Excluded were studies focused exclusively on high-income countries, those with no policy, governance, or pollution control component, editorials, opinion pieces, conference abstracts, theses, non-authoritative grey literature, non-English reports, and reports whose full text could not be retrieved. Global reports and conceptual literature cited in the Introduction and Section 1.1 provide context and were not treated as part of the evidence synthesis.

2.5 Study Selection

Records from all sources were consolidated, duplicates were removed, and the remainder were screened by title and abstract against the eligibility criteria above; the full texts of potentially eligible reports were then assessed and reasons for exclusion recorded, as shown in the PRISMA 2020 flow diagram (Table 1.1). The database searches returned 1,356 records (Scopus, 318; Web of Science, 264; ScienceDirect, 241; Google Scholar, 187; SpringerLink, 153; Wiley Online Library, 102; Taylor & Francis Online, 91), and 24 further reports were identified on the websites of international organizations. After 437 duplicates were removed, 943 records were screened, 116 full-text reports were assessed, and 29 sources were included in the review.

Table 1.1: PRISMA 2020 Flow Diagram of the Study Selection Process

IDENTIFICATION		
Records identified from: Databases (n = 1,356): Scopus, Web of Science, ScienceDirect, SpringerLink, Wiley Online Library, Taylor & Francis Online, Google Scholar Reports of international organizations (n = 24)	→	Records removed before screening: Duplicate records (n = 437)
SCREENING		
Records screened by title and abstract (n = 943)	→	Records excluded (n = 818)



Note. Adapted from Page *et al.* (2021).

2.6 Data Extraction and Quality Appraisal

For each included study, the following data were extracted into a structured evidence extraction table (Table 3.6): author(s) and year, country or region, environmental sector, type of evidence, and the focus and key contribution relating to policy effectiveness and implementation. The methodological quality of the included sources was appraised using tools matched to study design: the Mixed Methods Appraisal Tool (MMAT; Hong *et al.*, 2018) for empirical studies and the Risk of Bias in Systematic Reviews (ROBIS) tool (Whiting *et al.*, 2016) for review articles. Reports of international organizations were retained as authoritative grey literature.

2.7 Data Synthesis

Because the included studies differed in design, indicators, and outcome measures, a quantitative meta-analysis was not appropriate. The evidence was therefore synthesized narratively and thematically, organized by environmental sector (air, water, land and waste, industrial pollution prevention, and the circular economy) and by cross-cutting governance themes (policy strength, institutional capacity, technological innovation, stakeholder participation, and monitoring).

2.8 Survey Design and Data Collection

The quantitative strand used a cross-sectional questionnaire survey to obtain stakeholders' ratings of the effectiveness of environmental management programmes and pollution control measures. Its results are reported in Sections 3.1 to 3.6. In this illustrative sample, all survey values are hypothetical and are provided only to demonstrate the expected level of reporting.

2.8.1 Study Area and Target Population

The survey covered three purposively selected Nigerian states with contrasting pollution contexts: Anambra (the Onitsha and Nnewi industrial and commercial clusters), Lagos (the country's largest urban and industrial centre), and Rivers (the centre of oil and gas operations in the Niger Delta). The target population was 1,250 stakeholders: 390 environmental officers of NESREA and the state ministries and agencies responsible for the

environment; 360 health, safety, and environment (HSE) or operations managers of registered manufacturing and oil and gas firms; and 500 executive members of registered community development associations in industrial and host communities.

2.8.2 Sample Size and Sampling Technique

The sample size was determined with the Yamane (1967) formula (Equation 2.1) at a 5% margin of error:

$$n = \frac{N}{1 + Ne^2} \quad (2.1)$$

Substituting the values gives $n = 1,250 \div [1 + 1,250(0.05)^2] = 303.03$, so 303 respondents were sampled using a multistage procedure: states were selected purposively, the sample was allocated to respondent groups in proportion to their population (proportionate stratified sampling), and respondents within each group were randomly selected from agency staff lists, company registers, and association membership lists. Of the 303 questionnaires distributed, 286 were returned complete and valid, a response rate of 94.4% (Table 2.1), from Anambra ($n = 112$; 39.2%), Lagos ($n = 102$; 35.7%), and Rivers ($n = 72$; 25.2%) States.

Table 2.1: Population, Sample, and Response Rate by Respondent Group

Respondent group	Population	Questionnaires distributed	Valid returns	Response rate (%)
Environmental officers	390	95	94	98.9
Industrial managers	360	87	86	98.9
Community residents	500	121	106	87.6
Total	1,250	303	286	94.4

Note. Distribution by proportionate stratified sampling; response rate = valid returns $\div$ questionnaires distributed $\times$ 100 (Equation 2.5).

2.8.3 Research Instrument

Data were collected with the Environmental Policy Effectiveness Questionnaire (EPEQ), which had four sections and 28 rated items. Section A recorded respondent group and state; Section B (15 items) rated the effectiveness of each of the five programmes in controlling air, water, and land pollution; Section C (5 items) rated the contribution of five sources to environmental pollution; and Section D (8 items) rated environmental policy performance in each year from 2018 to 2025. Sections B and D used a five-point Likert scale (Joshi *et al.*, 2015): Very Effective (5), Effective (4), Moderately Effective (3), Ineffective (2), and Very Ineffective (1). Section C used the anchors Very High Contribution (5) to Very Low Contribution (1). The questionnaire was administered between November 2025 and January 2026, in person by four trained research assistants and by email to officers not available in person.

2.8.4 Validity and Reliability

The face and content validity of the questionnaire were established by three experts, two in environmental engineering and one in measurement and evaluation, whose comments led to the rewording of four items. Reliability was assessed with Cronbach's alpha (Cronbach, 1951), computed with Equation 2.2:

$$\alpha = \frac{k}{k-1} \left(1 - \frac{\sum \sigma_i^2}{\sigma_T^2} \right) \quad (2.2)$$

Here k is the number of items, σ_i^2 the variance of item i , and σ_T^2 the variance of the total score. A pilot test with 30 stakeholders in Enugu State, who were not part of the main sample, gave coefficients of 0.82 to 0.94, and the main sample gave 0.87 to 0.96 (Section B, 0.93; Section C, 0.87; Section D, 0.96; overall instrument, 0.89). All values exceed the commonly used threshold of 0.70 (Tavakol & Dennick, 2011), indicating good internal consistency.

2.8.5 Ethical Considerations

The study was approved by the Research Ethics Committee of the Faculty of Engineering, Chukwuemeka Odumegwu Ojukwu University (illustrative reference FERC/2025/014). Participation was voluntary, written informed consent was obtained from every respondent, no names or other personal identifiers were recorded, and the data were stored securely and used only for this study.

2.9 Statistical Techniques

All analyses were performed in Python with the NumPy and SciPy libraries, and statistical significance was assessed at the 0.05 level.

2.9.1 Descriptive Analysis

The mean score, $\bar{X} = \sum FX \div \sum F$ (2.3), where F is the frequency and X the assigned scale value, determined the effectiveness of programmes and strategies; the standard deviation, $SD = \sqrt{[\sum (X - \bar{X})^2 \div N]}$ (2.4), where X is an observation and N the number of observations, measured dispersion around the mean; and percentage analysis, $P = (F \div N) \times 100$ (2.5), where F is the frequency and N the total number of responses, described the distribution of respondents and the contribution of pollution sources.

2.9.2 Inferential Analysis

Because Likert-scale composite scores are ordinal and not normally distributed, differences in ratings across the three respondent groups and the three states were tested with the Kruskal–Wallis H test (Kruskal & Wallis, 1952), a non-parametric alternative to one-way analysis of variance (ANOVA), computed with Equation 2.6:

$$H = \frac{12}{N(N+1)} \sum \frac{R_j^2}{n_j} - 3(N+1) \quad (2.6)$$

H was evaluated against the chi-square distribution with $k - 1$ degrees of freedom, where k is the number of groups. Where H was significant, pairwise Mann–Whitney U tests with a Bonferroni correction were used to identify which groups differed.

3.0 RESULTS AND DISCUSSION

Sections 3.1 to 3.6 report the survey results ($n = 286$). Sections 3.7 and 3.8 report the systematic review (characteristics of the included studies and a thematic synthesis), and Section 3.9 integrates the two strands and discusses the findings in relation to the literature, policy implications, and sustainability objectives in Nigeria and Sub-Saharan Africa.

3.1 Effectiveness of Environmental Management Programmes

Table 3.1 and Figure 3.1 present the mean effectiveness scores that respondents assigned to the programmes. All scored above the 3.00 benchmark and within the 2.61–3.40 band of the Decision Rule, indicating that they are moderately effective. The Industrial Waste Management Programme scored highest (3.33), suggesting that industrial waste reduction, recycling, and treatment have contributed most to environmental sustainability; the NESREA Enforcement, Oil Spill Response, and Urban Waste Collection Programmes each scored 3.20, and the Environmental Sanitation Programme lowest (3.17). By domain, the Oil Spill Response Programme received the highest rating for water pollution control (3.43), the Urban Waste Collection Programme for land pollution control (3.40), and the Environmental Sanitation Programme the only below-benchmark rating (2.95, air pollution control), reflecting its focus on waste and drainage rather than emissions. None of the programmes has yet reached the Effective band (3.41–4.20).

Decision Rule: mean scores of 4.21–5.00 were interpreted as Very Effective, 3.41–4.20 as Effective, 2.61–3.40 as Moderately Effective, 1.81–2.60 as Ineffective, and 1.00–1.80 as Very Ineffective. The scale midpoint (3.00) is the acceptance benchmark: a mean of 3.00 or above denotes a favourable rating, whose level the Decision Rule grades.

Table 3.1: Mean Effectiveness Scores of Environmental Management Programmes (5-Point Likert Scale)

Programme	Air (Mean Score)	Water (Mean Score)	Land (Mean Score)	Average (Mean Score)	Decision
NESREA Enforcement Programme	3.20	3.30	3.10	3.20	Moderately Effective
Environmental Sanitation Programme	2.95	3.20	3.35	3.17	Moderately Effective
Industrial Waste Management Programme	3.30	3.35	3.35	3.33	Moderately Effective
Oil Spill Response Programme	3.03	3.43	3.14	3.20	Moderately Effective
Urban Waste Collection Programme	3.15	3.05	3.40	3.20	Moderately Effective
Domain mean	3.13	3.27	3.27	3.22	Moderately Effective

Note. $n = 286$. Each cell is the mean rating of one questionnaire item (Section B).

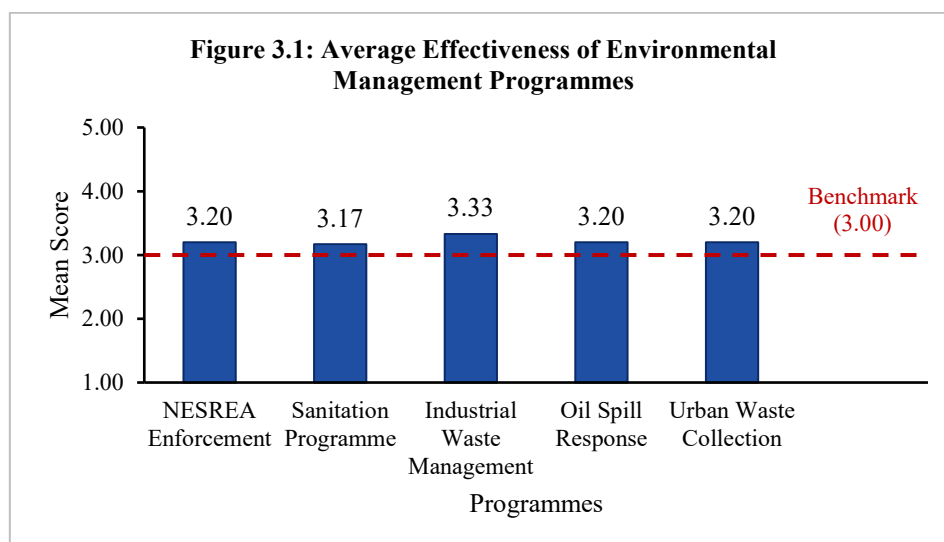


Figure 3.1: Average Effectiveness of Environmental Management Programmes

3.2 Descriptive Statistics of Pollution Control Measures

Table 3.2 shows the descriptive statistics for the pollution control measures. Water and land pollution control each recorded the highest mean (3.27) and air pollution control the lowest (3.13). All values exceed the 3.00 benchmark and fall within the 2.61–3.40 band, so respondents rated pollution control measures as moderately effective. Across the five programmes the standard deviations ranged from 0.12 to 0.13, indicating similar performance within each domain, although air pollution control ratings ranged from 2.95 to 3.30; item-level standard deviations of 1.00 to 1.12 show that respondents used the full width of the scale. Environmental policies have therefore achieved moderate success across sectors.

Table 3.2: Descriptive Statistics of Pollution Control Ratings Across the Five Programmes (5-Point Likert Scale)

Statistical Measure	Air Pollution (Mean Score)	Water Pollution (Mean Score)	Land Pollution (Mean Score)
Mean	3.13	3.27	3.27
Maximum	3.30	3.43	3.40
Minimum	2.95	3.05	3.10
Range	0.35	0.38	0.30
Standard Deviation	0.12	0.13	0.12

Note. Statistics are computed from the five programme means in each column of Table 3.1 (standard deviation by Equation 2.4). Benchmark Mean = 3.00. All three means fall within the Moderately Effective band (2.61–3.40) of the Decision Rule.

3.3 Major Sources of Environmental Pollution

Table 3.3 and Figure 3.2 present the major sources of environmental pollution. Industrial activities ranked first (3.35), followed by transportation (3.27), municipal waste (3.20), oil and gas operations (3.18), and agricultural activities (3.10). Industrialization thus remains the primary perceived contributor to environmental

degradation, and stricter regulation and cleaner production technologies are needed to curb pollution from the industrial and transport sectors.

Table 3.3: Mean Scores of Sources of Environmental Pollution (5-Point Likert Scale)

Source of Pollution	Mean Score	Rank
Industrial Activities	3.35	1
Transportation	3.27	2
Municipal Waste	3.20	3
Oil and Gas Operations	3.18	4
Agricultural Activities	3.10	5
Overall Mean Score	3.22	—

Note. $n = 286$ (questionnaire Section C). Benchmark Mean = 3.00. All sources are rated above the benchmark.

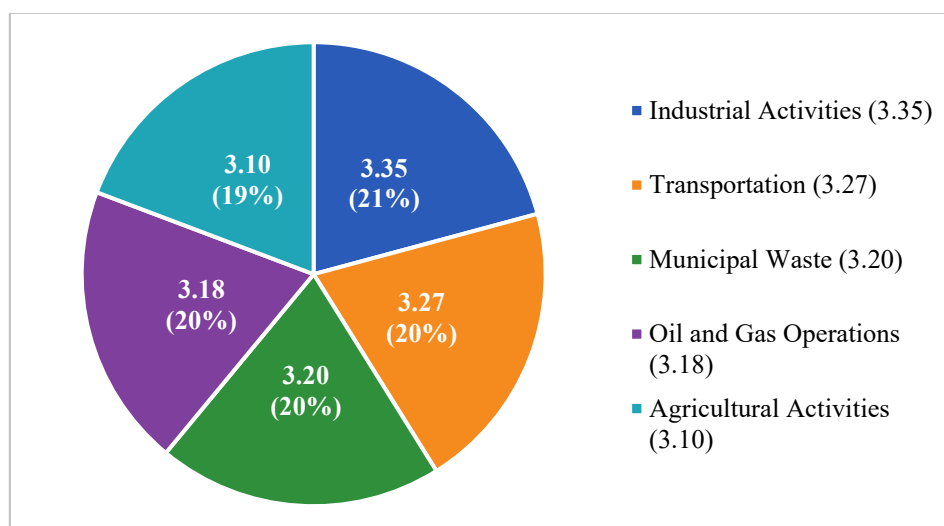


Figure 3.2: Sources of Environmental Pollution (Mean Scores)

3.4 Environmental Policy Performance Trend (2018–2025)

Table 3.4 and Figure 3.3 show policy performance between 2018 and 2025, based on respondents' retrospective ratings of each year (questionnaire Section D). Scores rose steadily from 3.10 in 2018 to 3.60 in 2025, an improvement of 0.50 points (the yearly change is the mean in year t minus the mean in year $t - 1$). Scores for 2018–2022 (3.10–3.35) fall within the Moderately Effective band and those for 2023–2025 (3.45–3.60) within the Effective band (3.41–4.20). The trend suggests continuing improvement in governance, implementation, and enforcement, which may reflect greater environmental awareness, stronger institutions, and increased governmental commitment.

Table 3.4: Environmental Policy Performance Trend (5-Point Likert Scale)

Year	Mean Score	Change from Previous Year	Decision
2018	3.10	–	Moderately Effective
2019	3.15	+0.05	Moderately Effective
2020	3.20	+0.05	Moderately Effective
2021	3.28	+0.08	Moderately Effective
2022	3.35	+0.07	Moderately Effective
2023	3.45	+0.10	Effective
2024	3.55	+0.10	Effective
2025	3.60	+0.05	Effective
Overall Improvement (2018–2025) = 3.60 – 3.10 = +0.50			

Note. Source: questionnaire Section D, in which each of the 286 respondents rated environmental policy performance in each year from 2018 to 2025 on the five-point scale. The scores are therefore retrospective ratings collected in a single survey, not repeated annual measurements.

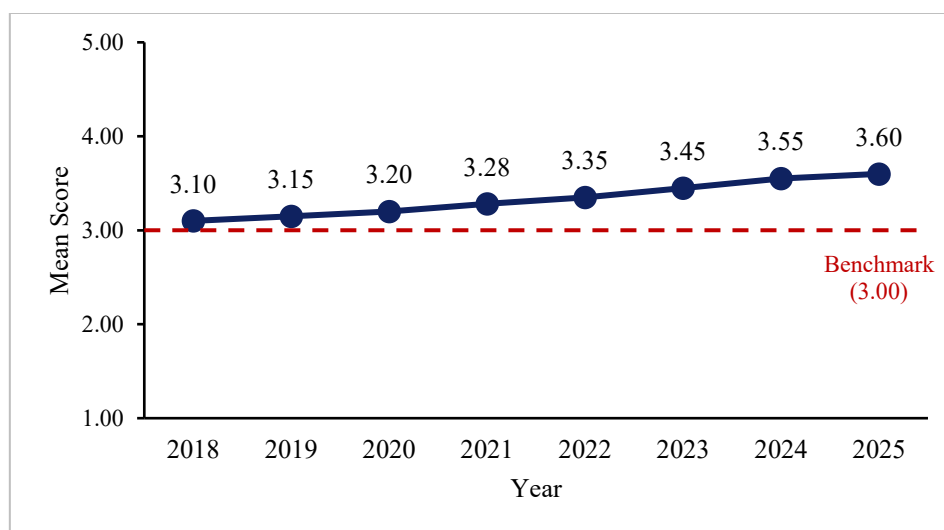


Figure 3.3: Trend of Environmental Policy Performance (2018–2025)

3.5 Environmental Performance Index (EPI)

The Environmental Performance Index (EPI) is a composite perception index adapted from the logic of national environmental performance indices (Wendling *et al.*, 2022). It is the mean of the air, water, and land pollution control scores in Table 3.2: $EPI = (3.13 + 3.27 + 3.27) \div 3 = 3.22$. This exceeds the 3.00 benchmark and falls within the Moderately Effective band (2.61–3.40), indicating that environmental management policies and pollution control strategies are moderately effective overall. Water and land pollution control scored highest (3.27) and air pollution control lowest (3.13), so performance is fairly balanced, but greater attention to air quality management and emission control is needed to reach higher levels of sustainability.

3.6 Differences in Ratings Across Respondent Groups

Table 3.5 presents the Kruskal–Wallis H tests (Equation 2.6) comparing effectiveness ratings across the three respondent groups. Ratings differed significantly for air pollution control, $H(2) = 14.35$, $p < .001$; water pollution control, $H(2) = 14.72$, $p < .001$; land pollution control, $H(2) = 12.65$, $p = .002$; and overall programme effectiveness, $H(2) = 15.82$, $p < .001$. In every domain, environmental officers gave the most favourable ratings (overall mean rank 167.5; mean score 3.45), industrial managers were intermediate (145.1; 3.23), and community residents gave the least favourable ratings (121.0; 3.01). Bonferroni-corrected pairwise Mann–Whitney U tests on the overall scores showed that the significant difference lay between environmental officers and community residents (adjusted $p < .001$), whereas differences involving industrial managers were not significant (adjusted $p = .163$ and $.104$). Ratings did not differ significantly across the three states for any domain ($H(2) = 0.20$ to 1.47 , $p = .480$ to $.907$), indicating that the perception gap is associated with stakeholder role rather than location.

Table 3.5: Kruskal–Wallis Test of Differences in Effectiveness Ratings Across Respondent Groups

Domain	Environmental officers ($n = 94$)	Industrial managers ($n = 86$)	Community residents ($n = 106$)	H	df	p
Air pollution control	166.2	145.1	122.0	14.35	2	< .001
Water pollution control	166.7	144.7	122.0	14.72	2	< .001
Land pollution control	164.9	144.9	123.4	12.65	2	.002
Overall programme effectiveness	167.5	145.1	121.0	15.82	2	< .001

Note. Values for the three groups are mean ranks ($N = 286$); higher ranks indicate more favourable ratings. Composite scores are the means of the five programme items in each domain (questionnaire Section B).

3.7 Characteristics of the Included Studies

Table 3.6 summarizes the evidence extracted from the 29 included sources, which comprise 15 review articles, 9 empirical studies, and 5 reports of international organizations. The evidence base combines peer-reviewed reviews and empirical studies with global and regional reports, and covers water, air, land and waste, climate, and circular economy themes, with a strong emphasis on Nigeria and Sub-Saharan Africa.

In the quality appraisal, seven of the nine empirical studies met at least four of the five MMAT criteria and two met three. Of the 15 review articles assessed with ROBIS, six were judged at low, seven at unclear, and two at high risk of bias, the last mainly because their search methods were not reported. The five reports of international organizations were retained as authoritative grey literature. No source was excluded on quality grounds, but findings from sources at high risk of bias were used only where other evidence corroborated them.

Table 3.6: Evidence Extraction Table for the Included Studies and Reports

Source	Region or Sector	Evidence type	Focus and key contribution
Amegah & Agyei-Mensah (2017)	Urban centres, Air Sub-Saharan Africa	Review	Documents urban air pollution and its sources, and argues for stronger policy action and monitoring
Ayeleru <i>et al.</i> (2020)	Sub-Saharan Africa	Waste (plastic) Review	Reviews plastic waste generation and management and the challenges that limit effective control
Onu <i>et al.</i> (2023)	Sub-Saharan Africa	Wastewater Review	Reviews wastewater generation and management and the challenges constraining treatment
Ferronato & Torretta (2019)	Developing countries	Waste Narrative review	Examines environmental contamination and social issues, including risks to informal waste workers, caused by waste mismanagement
Guerrero <i>et al.</i> (2013)	Cities in developing countries	Solid waste Review	Analyses the challenges facing solid waste management in developing-country cities
Kaza <i>et al.</i> (2018)	Global, with regional data	Solid waste Global report	Provides a global snapshot of waste generation and management to 2050, with rapid growth projected for Sub-Saharan Africa
Ighalo & Adeniyi (2020)	Nigeria	Water Review	Reviews water quality monitoring and assessment practices in Nigeria
Ighalo <i>et al.</i> (2021)	Nigeria	Water Systematic literature analysis	Analyses the nature and regional distribution of water pollution sources in Nigeria
Sam <i>et al.</i> (2016)	Nigeria	Land Framework analysis	Examines land contamination management and works towards an integrated management framework for Nigeria
Awewomom <i>et al.</i> (2024)	Global	Multiple Review	Reviews environmental control techniques, with a focus on environmental policy and preventive environmental management

Source	Region or scope	Sector	Evidence type	Focus and key contribution
Ogunbode (2026)	Nigeria	Water and sanitation	Critical review	Reviews Nigeria's progress towards Sustainable Development Goal 6 (2016–2024) and future strategies
Ogunbode <i>et al.</i> (2026)	Nigeria	Climate mitigation	Systematic review	Reviews climate change mitigation efforts in Nigeria
Okimiji <i>et al.</i> (2026)	Umuahia South and Aba South, Nigeria	Water (groundwater)	Empirical study	Examines groundwater pollution and environmental impacts associated with abattoir effluents
Olagunju <i>et al.</i> (2026)	Oyun River–Reservoir system, Offa, Nigeria	Water	Empirical study	Examines the socioenvironmental dynamics and determinants of riverscape pollution
Kirchherr <i>et al.</i> (2017)	Global	Circular economy	Content analysis	Analyses 114 definitions of the circular economy
Murray <i>et al.</i> (2017)	Global	Circular economy	Conceptual review	Explores the concept and application of the circular economy in a global context
UNEP & ISWA (2024)	Global	Waste	Global report	Assesses global waste management and frames waste as a resource
WHO (2021)	Global	Air	Guideline	Sets health-based global guideline levels for major air pollutants
AfDB (2022)	Africa	Climate and energy	Regional report	Examines climate resilience and a just energy transition in Africa
Blackman (2010)	Developing countries	Multiple	Review	Reviews alternatives to conventional command-and-control pollution regulation where enforcement capacity is weak
Anejionu <i>et al.</i> (2015)	Niger Delta, Nigeria	Air	Empirical study (remote sensing)	Quantifies spatial and temporal variation in gas flaring and its contribution to an air pollution hotspot
Croitoru <i>et al.</i> (2020)	Lagos, Nigeria	Air	Empirical study (valuation)	Estimates the health cost of ambient air pollution in Lagos

Source	Region or scope	or	Sector	Evidence type	Focus and key contribution
Fisher <i>et al.</i> (2021)	Africa		Air	Empirical study (burden estimation)	Estimates the health, economic, and human capital impacts of air pollution in Africa
Amann <i>et al.</i> (2020)	Global, regional results	with	Air	Empirical study (scenario modelling)	Models the scope for further air pollution policy interventions and their benefits
Nriagu <i>et al.</i> (2016)	Niger Delta, Nigeria		Oil pollution	Review	Reviews the health risks associated with oil pollution in the Niger Delta
UNEP (2011)	Ogoniland, Nigeria		Land and water (oil)	Environmental assessment report	Documents hydrocarbon contamination of land and groundwater and recommends clean-up and governance measures
Ike <i>et al.</i> (2018)	Nigeria		Solid waste	Review	Reviews the problems, prospects, and policies of solid waste management in Nigeria
Godfrey <i>et al.</i> (2020)	Africa		Solid waste	Review (book chapter)	Frames African solid waste management as a governance failure and a development opportunity
Jambeck <i>et al.</i> (2015)	Global, including African coastal countries		Plastic waste	Empirical study (modelling)	Estimates mismanaged plastic waste entering the ocean from coastal countries

Note. *N* = 29 sources, matching the included total in Figure 2.1. UNEP = United Nations Environment Programme; ISWA = International Solid Waste Association; WHO = World Health Organization; AfDB = African Development Bank.

3.8 Thematic Synthesis of the Evidence

3.8.1 Air pollution control

Urban air pollution in Sub-Saharan African cities is driven mainly by vehicular traffic, industry, biomass combustion, and open waste burning, and limited monitoring capacity and weak policy response have constrained control (Amegah & Agyei-Mensah, 2017). In Nigeria, gas flaring has created a regional air pollution hotspot in the Niger Delta (Anejionu *et al.*, 2015), and fine particulate matter in Lagos was estimated to have caused about 11,200 premature deaths and a health cost of US\$2.1 billion, about 2.1% of the state's gross domestic product, in 2018 (Croitoru *et al.*, 2020). Across Africa, air pollution is linked to a heavy burden of disease and to losses in output and human capital (Fisher *et al.*, 2021), while scenario modelling shows that

proven policy measures could still deliver large reductions in exposure (Amann *et al.*, 2020). Air quality standards are thus only as effective as the monitoring networks and enforcement capacity that support them.

3.8.2 Water pollution and wastewater management

Nigerian studies identify industrial and municipal discharges, agriculture, and petroleum-related contamination as major water pollution sources, with marked regional differences (Ighalo *et al.*, 2021), and underline the central role of reliable monitoring in identifying pollution and evaluating policy performance (Ighalo & Adeniyi, 2020). The environmental assessment of Ogoniland documented extensive hydrocarbon pollution of land and groundwater and called for sustained clean-up and stronger regulatory oversight (UNEP, 2011), and oil pollution in the Niger Delta has been associated with health risks (Nriagu *et al.*, 2016). Site-level studies show abattoir effluents polluting groundwater in south-eastern Nigeria (Okimiji *et al.*, 2026) and socioenvironmental influences on pollution in the Oyun River–Reservoir system (Olagunju *et al.*, 2026). Regionally, wastewater generation and management remain a major challenge (Onu *et al.*, 2023), and Ogunbode (2026) reviews Nigeria's 2016–2024 progress towards Sustainable Development Goal (SDG) 6 on clean water and sanitation and sets out strategies for further progress.

3.8.3 Land pollution and waste management

Waste generation in Sub-Saharan Africa is projected to grow rapidly (Kaza *et al.*, 2018). Institutional, financial, and technical constraints are recurring barriers to solid waste management in developing countries (Guerrero *et al.*, 2013), and mismanagement contaminates air, soil, and water and exposes informal waste workers to occupational risks (Ferronato & Torretta, 2019). In Nigeria, weak enforcement, inadequate funding, and limited infrastructure constrain waste policy (Ike *et al.*, 2018), and across Africa the shortfall in waste services has been characterized as a governance failure that also offers development opportunities (Godfrey *et al.*, 2020). Plastic waste is a growing concern (Ayeleru *et al.*, 2020), and several African coastal countries rank among the larger sources of mismanaged plastic entering the ocean (Jambeck *et al.*, 2015). For land pollution, the call for an integrated land contamination management framework in Nigeria (Sam *et al.*, 2016) points to the need for coordinated policy and regulation.

3.8.4 Prevention, circular economy, and cross-cutting governance themes

Awewomom *et al.* (2024) review environmental control techniques with a focus on environmental policy and preventive management, consistent with the shift from end-of-pipe control towards pollution prevention, and Nigeria's climate change mitigation efforts have been reviewed systematically (Ogunbode *et al.*, 2026), reflecting the integration of pollution control with climate and energy transition agendas (AfDB, 2022). The circular economy has been defined in many ways, with Kirchherr *et al.* (2017) analysing 114 definitions, and applies across disciplines and contexts (Murray *et al.*, 2017); global assessments increasingly frame waste as a resource and support a transition from linear disposal towards prevention, reuse, and recovery (UNEP & International Solid Waste Association [ISWA], 2024). Across sectors, policy frameworks exist, but their effectiveness depends on monitoring infrastructure, institutional capacity, and financing (Amegah & Agyei-Mensah, 2017; Guerrero *et al.*, 2013; Ogunbode, 2026). Where enforcement capacity is limited, command-and-control regulation tends to underperform, and complementary instruments such as information disclosure, voluntary agreements, and community pressure can improve compliance (Blackman, 2010).

3.9 Discussion

The findings show that environmental sustainability in Nigeria and Sub-Saharan Africa depends on the interaction of governance systems, economic development, technological capacity, and institutional effectiveness. The survey results converge with the review evidence. Respondents rated all programmes and pollution control domains as moderately rather than highly effective (Sections 3.1, 3.2, and 3.5), consistent with the implementation gaps, weak enforcement, and limited monitoring capacity documented in the literature (Amegah & Agyei-Mensah, 2017; Guerrero *et al.*, 2013; Ogunbode, 2026). Air pollution control received the lowest rating (3.13), in line with evidence that limited monitoring and weak policy response constrain control in Sub-Saharan African cities (Amegah & Agyei-Mensah, 2017), and industrial activities were ranked the leading pollution source, consistent with the prominence of industrial discharges among Nigerian water pollution sources (Ighalo *et al.*, 2021).

The significant differences between respondent groups (Section 3.6) add an important dimension. Environmental officers, who implement the programmes, rated them more favourably than the community residents who experience pollution directly, and the gap was consistent across all three states. This echoes the argument that environmental governance depends on the involvement and trust of affected communities, not only on state agencies (Lemos & Agrawal, 2006), and strengthens the case for participatory monitoring and transparent reporting of compliance data.

Although policies have expanded considerably over the past two decades, implementation gaps persist: the continuing air pollution, water contamination, and waste management problems indicate that policy formulation alone is insufficient without effective enforcement. The results also support integrated environmental governance, in which government agencies, industries, communities, research institutions, and international development partners act in coordination.

The review also highlights the need to move from traditional pollution control towards preventive and circular economy-based strategies (Kirchherr *et al.*, 2017; UNEP & ISWA, 2024), which can reduce environmental impacts while promoting growth and resource efficiency, consistent with the argument that well-designed regulation can stimulate innovation and competitiveness (Porter & van der Linde, 1995). The informal recycling sector, which already recovers a substantial share of materials in many developing-country cities, is a practical starting point (Wilson *et al.*, 2006).

Drawing on the synthesized evidence and the conceptual framework in Section 1.1, this study proposes the Environmental Governance Effectiveness Framework (EGEF), which identifies five interdependent determinants of environmental sustainability: policy strength, which establishes enforceable standards; institutional capacity, which converts standards into inspection, monitoring, and enforcement; technological innovation, including cleaner production and circular economy approaches, which reduces pollution at source; stakeholder participation, which strengthens accountability and compliance; and continuous evaluation, supported by monitoring systems, which allows policies to be assessed and adjusted. Weakness in any one determinant limits the others, which helps to explain why countries with comprehensive legislation but weak enforcement continue to record poor environmental outcomes.

This study has limitations. Restricting the search to English-language publications and selected databases may have excluded relevant studies; heterogeneity of designs, indicators, and contexts precluded quantitative pooling, so the conclusions reflect a narrative synthesis; and the evidence is unevenly distributed across countries and sectors, so generalization to other Sub-Saharan African settings should be cautious. The survey relies on self-reported perceptions from a cross-sectional sample, which may be affected by response bias and describes perceived rather than measured performance, and the trend in Table 3.4 rests on retrospective ratings that may be affected by recall bias.

4.0 CONCLUSION

This study assessed the effectiveness of environmental management policies and pollution control strategies in Nigeria and selected Sub-Saharan African countries through a systematic review of scholarly literature, policy documents, institutional reports, and empirical studies, complemented by a questionnaire survey of 286 stakeholders. Substantial progress has been made in environmental policies, regulations, and institutions: governments have established environmental protection agencies, enacted environmental laws, adopted environmental impact assessment procedures, and joined international environmental agreements.

The survey results corroborate this assessment. Respondents rated all programmes and pollution control domains as moderately effective, with an overall Environmental Performance Index of 3.22 on a five-point scale, rated air pollution control lowest, and identified industrial activities as the leading source of pollution. Environmental officers rated the programmes significantly more favourably than community residents, pointing to a gap between official and community perceptions. Although policy performance ratings rose between 2018 and 2025, none of the individual programmes has yet reached the Effective band.

Despite this progress, pollution remains a significant challenge: air pollution from transportation, industry, biomass burning, gas flaring, and open waste burning; water pollution from industrial discharges, inadequate wastewater treatment, agricultural runoff, mining, and petroleum exploration; and land pollution from poor solid waste management. The effectiveness of policies depends largely on institutional capacity, regulatory enforcement, financial resources, technological innovation, stakeholder participation, and political commitment, and although many countries have comprehensive legislation, implementation is weakened by inadequate funding, limited technical expertise, insufficient monitoring infrastructure, corruption, and institutional fragmentation.

Sustainable environmental management cannot be achieved through regulation alone. It requires integrated strategies that combine effective governance, cleaner production technologies, monitoring systems, circular economy principles and resource recovery (Kirchherr *et al.*, 2017; UNEP & International Solid Waste Association [ISWA], 2024), public awareness, and private-sector participation. Countries that have invested in environmental infrastructure, research, innovation, and institutional strengthening generally show better environmental performance.

In conclusion, greater emphasis must be placed on implementation, enforcement, technological advancement, and institutional effectiveness, supported by a coordinated, multidisciplinary approach among governments, industries, communities, researchers, and international development partners, in order to protect ecosystems, safeguard public health, and secure environmental sustainability for present and future generations.

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