Interrogating Waste Management and Sustainable Development of Ebonyi State

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Abstract

The study examined waste management and sustainable development of Ebonyi State. The specific objectives of the study were to: evaluate the effect of recycling initiatives on sustainable development of Ebonyi State, ascertain the effect of Waste-to-Energy (WtE) on sustainable development of Ebonyi State and examine the effect of Material Recovery Facilities (MRFs) on sustainable development of Ebonyi State. The study adopted a survey research design. The population of the study was 968,300. The sample size for the study was 400. The Chi-square test was applied in testing the hypotheses. The finding revealed that Recycling initiatives have a significant effect on the sustainable development of Ebonyi State, that Waste-to-Energy (WtE) projects have a significant effect on the sustainable development of Ebonyi State and that Material Recovery Facilities (MRFs) have a significant effect on the sustainable development of Ebonyi State. The study concluded that effective waste management is pivotal to the sustainable development of Ebonyi State. Implementing innovative waste management strategies, including recycling initiatives, Waste-to-Energy (WtE) projects, and Material Recovery Facilities (MRFs), significantly enhances environmental sustainability, resource conservation, and economic growth. Recycling and WtE technologies reduce landfill use, conserve energy, and lower greenhouse gas emissions, while MRFs improve recycling efficiency and support local employment. The study recommends among others that to expand and improve recycling infrastructure across Ebonyi State to increase material recovery rates. Invest in public education campaigns to raise awareness and encourage active participation in recycling initiatives, thus boosting overall environmental sustainability.

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1. Introduction

Waste management plays a crucial role in sustainable development by minimizing environmental impact, conserving natural resources, and promoting economic efficiency. Proper waste management practices, such as recycling, composting, and waste-to-energy conversion, reduce the volume of waste sent to landfills, thereby lowering greenhouse gas emissions and mitigating climate change. According to the United Nations Environment Programme (2023), effective waste management is essential for achieving the Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production). By recovering materials and energy from waste, waste management systems contribute to a circular economy, where resources are reused and recycled, reducing the need for virgin materials and minimizing environmental degradation. This approach not only conserves resources but also creates economic opportunities and jobs, particularly in the recycling and renewable energy sectors. Furthermore, proper waste disposal and management prevent pollution of air, soil, and water bodies, thereby protecting human health and ecosystems. As noted by Global Waste Management Outlook (2022), inadequate waste management in many developing countries exacerbates environmental and health issues, highlighting the need for sustainable waste management solutions. In conclusion, waste management is integral to sustainable development, ensuring that economic growth is achieved without compromising environmental integrity or social well-being.

The current state of waste management in Nigerian cities presents significant challenges to sustainable development, as rapid urbanization and population growth have outpaced infrastructure development. Many cities in Nigeria struggle with inadequate waste collection systems, leading to the accumulation of waste in public spaces, waterways, and unauthorized dumpsites. This has severe implications for public health, environmental sustainability, and urban livability. According to the World Bank (2023), only about 40-50% of waste generated in Nigerian cities is collected, with a significant portion of it being improperly disposed of, contributing to environmental pollution and greenhouse gas emissions. The inefficiency in waste management systems hampers efforts to achieve Sustainable Development Goals (SDGs) such as SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production). Despite some initiatives by the government and private sector to improve waste management, challenges such as inadequate funding, poor public awareness, and weak regulatory enforcement persist. The Nigerian Urban Reproductive Health Initiative (NURHI, 2022) notes that waste management in Nigerian cities requires a holistic approach, incorporating waste reduction, recycling, and public education.

Innovative solutions like waste-to-energy projects and community-based recycling programs are emerging but remain limited in scale. To enhance sustainable development, there is an urgent need for comprehensive waste management reforms that integrate modern technology, effective policy frameworks, and community participation. Waste management in Ebonyi State, Nigeria, significantly impacts the region's sustainable development. The state faces numerous challenges, including inadequate waste collection, improper disposal methods, and limited recycling facilities, which collectively threaten environmental sustainability and public health. Poor waste management practices contribute to environmental degradation, such as the contamination of water bodies and soil, and the proliferation of disease vectors, which undermines the well-being of communities. According to the Ebonyi State Waste Management Authority (2023), the state collects only about 60% of its generated waste, with much of the remainder ending up in unauthorized dumpsites or open spaces. This inefficiency hampers the achievement of Sustainable Development Goals (SDGs) like SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production), both critical to Ebonyi's development. The lack of sustainable waste management practices also results in lost economic opportunities, particularly in the areas of recycling and waste-to-energy initiatives, which remain underdeveloped in the state. Addressing these issues requires the implementation of comprehensive waste management strategies, including public education, improved infrastructure, and stronger regulatory frameworks. Recent efforts by the state government

to enhance waste management systems are steps in the right direction, but sustained efforts and broader community involvement are crucial for long-term sustainable development in Ebonyi State.

1.2 Statement of the Problem

The growing challenges of waste management in Ebonyi State, Nigeria, pose significant threats to sustainable development, affecting environmental quality, public health, and economic growth. As the state experiences rapid urbanization and population growth, the volume of waste generated has surged, overwhelming existing waste management systems. The inefficiency in waste collection, coupled with improper disposal practices, has led to the proliferation of illegal dumpsites, open burning of waste, and contamination of water bodies and soil. This situation exacerbates environmental degradation, undermining efforts to achieve Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production).

Despite the efforts by the Ebonyi State Waste Management Authority, the current waste management practices remain inadequate, with only about 60% of waste being properly collected and managed (Ebonyi State Waste Management Authority, 2023). The remaining waste often ends up in unauthorized dumpsites or is improperly disposed of, contributing to the spread of diseases and health issues within communities. Moreover, the lack of robust recycling initiatives and waste-to-energy programs means that valuable resources are lost, and potential economic benefits are unrealized.

This problem is further compounded by weak regulatory enforcement, inadequate public awareness, and insufficient infrastructure, which hinder the adoption of sustainable waste management practices. If not addressed, the implications of poor waste management will continue to impede the state's socio-economic development, leading to deteriorating living conditions and increased vulnerability to environmental hazards. Therefore, there is an urgent need for comprehensive waste management reforms in Ebonyi State to ensure sustainable development and improve the quality of life for its residents.

1.3 Objectives of the Study

The broad objective of the study is to examine the waste management and sustainable development of Ebonyi State. The specific objectives of the study were to:

i. Evaluate the effect of recycling initiatives on sustainable development of Ebonyi State
ii. Ascertain the effect of Waste-to-Energy (WtE) on sustainable development of Ebonyi State
iii. Examine the effect of Material Recovery Facilities (MRFs) on sustainable development of Ebonyi State

1.4 Research questions

The following research questions were posed for the study:

i. How does recycling initiatives affect sustainable development of Ebonyi State?
ii. What is the effect of Waste-to-Energy (WtE) on sustainable development of Ebonyi State?
iii. What effect does Material Recovery Facilities (MRFs) on sustainable development of Ebonyi State?

1.5 Hypotheses

The following null research hypotheses were formulated for the study

i. Recycling initiatives have no significant effect on the sustainable development of Ebonyi State.
ii. Waste-to-Energy (WtE) projects have no significant effect on the sustainable development of Ebonyi State.
iii. Material Recovery Facilities (MRFs) have no significant effect on the sustainable development of Ebonyi State.

2. Review of Related Literature

Conceptual Review

Waste Management

Waste management refers to the systematic approach to handling, processing, and disposing of waste materials in a manner that minimizes their impact on the environment, human health, and the economy. The concept encompasses a range of activities, including the collection, transportation, treatment, and disposal of waste, as well as recycling, composting, and energy recovery. Effective waste management aims to reduce the volume of waste generated, promote the reuse and recycling of materials, and ensure that waste disposal is conducted in an environmentally sustainable manner. Recent advancements in waste management emphasize the importance of sustainable practices that align with the principles of the circular economy, where waste is seen as a resource rather than a burden. Technologies such as waste-to-energy conversion, advanced recycling techniques, and the development of biodegradable materials are increasingly being integrated into waste management strategies (Smith & Turner, 2023). Additionally, policy frameworks and regulations play a critical role in guiding waste management practices, particularly in urban areas where waste generation is high (Jones et al., 2024). Proper waste management is essential for mitigating environmental pollution, conserving natural resources, and promoting public health. As global waste production continues to rise, innovative and sustainable waste management solutions are increasingly necessary to address the associated challenges.

Waste Recycling

Waste recycling is the process of converting waste materials into new, usable products, thereby reducing the need for raw materials, conserving energy, and minimizing environmental impact. It involves the collection, sorting, and processing of recyclable materials such as paper, plastic, glass, and metals, which are then remanufactured into new products. Recycling is a key component of waste management and the circular economy, as it helps to close the loop by reintroducing materials back into the production cycle, reducing the demand for natural resources (Jones & Smith, 2023).

Recent developments in recycling technology have significantly improved the efficiency and effectiveness of the process. Advanced sorting technologies, such as artificial intelligence and robotics, are now being used to separate materials more accurately, leading to higher recycling rates (Nguyen et al., 2024). Additionally, the recycling of complex materials, such as electronic waste, has become more feasible with innovations in material recovery and processing techniques. Recycling plays a crucial role in reducing landfill use, lowering greenhouse gas emissions, and conserving natural resources. As global waste production increases, the importance of recycling as a sustainable waste management strategy continues to grow, prompting ongoing research and development in this field.

Waste-to-Energy (WtE)

Waste-to-Energy (WtE) is a process that converts municipal solid waste (MSW) into energy, typically in the form of electricity, heat, or fuel. This technology is an integral part of modern waste management strategies, providing a dual benefit of waste reduction and energy production. The process involves the combustion of waste materials, which generates heat that can be used to produce steam, drive turbines, and generate electricity (Zhao & Wang, 2023). WtE plants can significantly reduce the volume of waste destined for landfills by up to 90%, making it a viable solution for waste management in urban areas with limited landfill space. Additionally, WtE contributes to the circular economy by recovering valuable energy from waste, which would otherwise be lost (Anderson, 2024).

Recent advancements in WtE technology have improved the efficiency of energy recovery and reduced the environmental impact of emissions through advanced filtration and gas-cleaning systems. These improvements make WtE a more sustainable option compared to traditional waste disposal methods (Li et al., 2024). However, WtE still faces challenges, such as high operational costs and public concerns about emissions, making ongoing research and policy support crucial for its broader adoption.

Material Recovery Facilities (MRFs)

Material Recovery Facilities (MRFs) are specialized plants that receive, sort, and prepare recyclable materials for sale to end-user manufacturers. These facilities play a crucial role in the recycling process by efficiently separating mixed waste streams into distinct categories such as paper, plastics, metals, and glass, which can then be processed into new products. MRFs are designed to handle both single-stream and dual-stream recycling systems, where recyclable materials are either mixed or partially sorted before arriving at the facility (Smith & Johnson, 2023).

Modern MRFs utilize advanced technologies such as conveyor belts, magnets, air classifiers, and optical sorters to automate and enhance the accuracy of the sorting process. This automation not only increases the efficiency of recycling operations but also improves the purity of the recovered materials, which is critical for maintaining the quality of recycled products (Nguyen et al., 2024). The development and optimization of MRFs are essential for enhancing the overall effectiveness of recycling programs, reducing the amount of waste sent to landfills, and supporting the circular economy. Ongoing innovations in MRF technology continue to address challenges related to contamination and the processing of complex materials.

Sustainable Development

Sustainable development is a holistic approach to growth that seeks to meet the needs of the present without compromising the ability of future generations to meet their own needs. It balances economic development, social inclusion, and environmental protection to ensure long-term prosperity and well-being. This concept was popularized by the 1987 Brundtland Report, which emphasized the interdependence of economic, social, and environmental goals (Brundtland Commission, 1987).
In recent years, sustainable development has been operationalized through the United Nations' Sustainable Development Goals (SDGs), a global framework comprising 17 goals aimed at addressing challenges like poverty, inequality, climate change, environmental degradation, and peace (United Nations, 2023). These goals emphasize the need for integrated approaches that link economic growth with social equity and environmental stewardship.

Theoretical Framework
Theory of Ecological Modernization

The Theory of Ecological Modernization was propounded by sociologists Joseph Huber and Martin Jänicke in the early 1980s. The theory asserts that economic development and environmental protection are not necessarily at odds; instead, they can be synergistically linked through modernization processes. The central tenets of Ecological Modernization include the belief that technological innovation, economic restructuring, and environmental policy reform can lead to more sustainable industrial practices. The Theory of Ecological Modernization is highly relevant to the study of waste management and sustainable development in Ebonyi State. This theory posits that environmental protection and economic development can be mutually reinforcing through the modernization of production and consumption processes. Ecological modernization suggests that technological innovation, regulatory frameworks, and market-based approaches can lead to more sustainable practices, reducing environmental degradation while promoting economic growth.
The theory emphasizes the role of governments, industries, and consumers in driving environmental improvements. Key aspects include the integration of environmental considerations into economic

decision-making, the development of clean technologies, and the promotion of market-based instruments to achieve sustainability. Ecological Modernization also highlights the potential for green growth, where economic progress and environmental sustainability go hand in hand, creating a pathway towards a more sustainable future. This approach has influenced environmental policies and practices globally since its inception.
In the context of waste management in Ebonyi State, this theory supports the idea that adopting advanced waste management technologies, such as recycling systems and waste-to-energy processes, can enhance environmental sustainability and contribute to economic development. By integrating ecological considerations into policy and industrial practices, Ebonyi State can improve waste management, reduce pollution, and support sustainable development goals.

The theory emphasizes the role of governmental policies, business innovations, and public participation in achieving sustainable outcomes. It aligns well with the objectives of sustainable development, which aim to balance environmental protection with economic and social progress, making it a fitting theoretical framework for studying waste management and sustainable development in Ebonyi State.

Empirical Review

Uzoagu and Eheazu (2022) examined the Waste Management and Environmental Protection for Community Sustainable Development in Nigeria. The negative consequences of economic development have long been observed by eminent economic theorists, such as Smith, Marx, Malthus, Ricardo and Mill (Clarin, 2018). There are some indicators that show that most countries have failed to achieve sustainable development, and some countries are far from it. There has also been a growing concern about the environmental limit to growth and development as well as the imperative of environmental quality and management. The paper further discussed the composition of waste materials in Nigeria. It again examined various international and national measures or activities taken in relation to the concept of community sustainable development. The scholars in addition discussed the rationale for environmental protection and the negative impacts of waste on Nigerian environment. Furthermore, several measures taken internationally and nationally to ameliorate the negative impacts of wastes on environment were concisely discussed.

Abdoulkadri, Fatoumata & Issa (2022) investigated the Population growth and solid waste generation in the urban municipality of Gao, Mali. The methodology adopted consisted of a bibliographical analysis, field surveys of actors in the waste sector and surveys of the GPS points of the main dumps (official and anarchic). The results show that the quantity of waste produced per person per day has increased from 0.5 kg in 2009 to 0.9 kg in 2020. Thus, the total production of solid waste in the urban municipality of Gao has respectively increased from 43.17 tons at 109.85 tons per day. As the community is not prepared to receive such a human wave, the waste has become more cumbersome and the infrastructure, equipment and appropriate storage areas are lacking. This results in a deterioration of the living environment of the populations and the increase in diseases such as malaria, typhoid fever and respiratory infections, which constitutes a significant health risk.

Oke, Gbadebo and Olatunji (2022) examined the effects of population growth and urbanization on economic growth in Nigeria. To achieve the specific objectives, the OLS estimation techniques employed are Autoregressive Distributed Lag (ARDL), Fully Modified OLS (FMOLS), and granger causality to test the causal direction of the model variables. While the ARDL estimates the short-run and long-run impact, the FMOLS estimates the long-run effects of population growth and urbanization on economic growth. Lastly, the granger causality test helps to identify the policy directions in this study. Findings revealed that population growth has a positive and significant effect on economic growth in both the short-run and long-run, while urbanization has a negative and insignificant effect on economic growth in the short-run and the long-run over the study periods.

Fatai, (2021) focused on analysis of Urban Expansion and Land Cover Changes in Lagos Metropolis, Nigeria. The study uses Landsat imageries for 1995, 2000 and 2015 collected from United State Geological Survey (USGS) for analyzing the land use and land cover in the study area. The Landsat images were classified using supervised classification. Results reveal that between year 1995 and 2000, the land use land cover shows that there is less than 20% built up areas and more than 70% significant change in the land use land cover for bare ground, vegetation and water body respectively. In contrast, in the year 2015, there was more than 40% increase in built up areas and less than 60% bare ground, vegetation and water body respectively. At the aggregate level, there was more than 20% increase in built up areas between 1995, 2000 and 2015 and 8% decreased in bare ground between 1995, 2000 and 2015.

Ayodeji, Afolalu, Olabisi, Moses, Emetere, Ongbali, Olamilekan, Oloyede, & Banjo (2021). Impact assessment of the current waste management practices in Nigeria. The study presents a systematic review of existing literature, significant aspects of the existing novels was assessed: waste characterization, waste management practices, ecological impacts, public-private partnership, ethical issues, and legal framework and challenges militating against the current waste practices. This study shows that the existing waste management methods are ineffective and the demand for an all-inclusive waste management approach, proper execution, and enforcement of environmental regulations and laws. Waste management practices differ from nation to nation depending on the waste sources, types, and characteristics. It plays a vital role in nature's ability to sustain life within its capability. In many developing nations of the world, it has become a recurrent challenge, especially in urban areas. Waste generation in Nigeria is on the increase due to the rise in population resulting from the techno-economic development in cities and the pattern of production and consumption of materials. The current waste management practices in the nation are fast becoming a national issue and unsustainable, leading to apparent environmental risk.

Maidodo, Azizan and Abdullahi (2019) examined the urban solid waste Development: A review of Nigeria's Waste Management Policy. The paper dissected the existing policy structure on urban waste management in Nigeria and elucidates the provision of strong and appropriate policies, judicial decision and government intercessions that help a rights-based comprehension of waste management and disposal in Nigeria. The paper was of the view that the continually rising worldwide concern on ecological wellbeing requires that wastes be appropriately administered and discarded harmoniously and satisfactorily. This would minimize, and where possible dispense its potential damage to people, plants, animals and natural resources. Urban solid waste management development in Nigeria can be traced the back to late 1980s. With the rise in population, urbanization, and industrialization alongside globalization, the challenge of urban solid waste management (USWM) has escalated with its attendant human and environmental problems that need to be attended to.

Bucci et al. (2019) examined the "dilution effect" of population growth on per-capita human capital formation. The dilution effect (discussed in respect of average years of schooling at the individual level and average human capital at the aggregate level) examined the addition of new-borns (who are uneducated) which then reduced both the long-run and short-run level of physical capital per capita.

Furuoka (2016) examined the advantage of high population growth in the Indian economy. Using ARDL, the study also found a negative long-run relationship between population growth and economic growth and recommended that a continued increase in population may be detrimental to the Indian economy.

3. Methodology

Research Design

The study adopted a survey research design. A survey design was concerned with determining the frequency with which something occurs or the relationship between variables.

Sources of Data

Primary data for this study were information gathered directly from respondents through structured questionnaires and interviews while secondary data were sourced from publications.

Area of the Study

This research was conducted in Ebonyi metropolis.

Population of the Study

The population of the study includes all the residents of Ebonyi metropolis. The population of the study was **955,300.**

Table 3.1 Population Distribution Table

Ebonyi Metropolis	Population	Percentage
Ebonyi East	374,100	39
Ebonyi North	326,900	34
Ebonyi South	267,300	27
Total	968,300	100

Source: National Population Commission project for 2021

Determination of Sample Size

The sample size is 400

Sampling Techniques

The study adopted simple random techniques where the total population has equal chance of been selected. The structured questionnaire was adopted to collect data from the respondents from the four health institutions. The questionnaire was made up of 4 points scale: Very High extent (VH), High Extent (HE), Undecided (U), Low Extent (LE), Very Low Extent (VLE). For each variable, there were (items/elements) which were deployed keeping in view the questionnaire filling culture and understanding of the population.

Method of Data Analyses

The study employed inferential and descriptive statistics, inferential statistic tool used for the study was Chi-square test while descriptive frequency distribution and mean score was employed.

4. Date Presentation and Analysis

This section deals with the data analysis and interpretation of the findings. 400 copies questionnaire were distributed to the respondents and 378 were returned.

Data Analysis

Table 1: How recycling initiatives affect sustainable development of Ebonyi State

s/n	Options	Very High	High	Undecided	Low Extent	Very Low Extent	FREQ	Mean	Decision
1	Recycling reduces the need for raw materials, preserving natural resources like forests and minerals for future generations.	160 (42%)	175 (46%)	13 (3%)	30 (8%)	10 (3%)	378	4.3	Accepted
2	Recycling materials often require less energy than producing new ones, contributing to energy conservation and reducing carbon emissions.	140 (37%)	180 (48%)	20 (5%)	38 (10%)	10 (3%)	378	4.1	Accepted
3	Recycling initiatives create jobs in collection, processing, and manufacturing industries, boosting the local economy and supporting livelihoods.	190 (50%)	118 (31%)	10 (3%)	40 (10%)	20 (6%)	378	4.4	Accepted
4	By diverting waste from landfills, recycling minimizes environmental pollution, promoting a cleaner and healthier environment in Ebonyi State	200 (53%)	118 (31%)	10 (3%)	25 (7%)	25 (7%)	378	4.1	Accepted
5	Recycling programs educate residents about sustainable practices, fostering a culture of	150 (38%)	160 (42%)	10 (3%)	38 (6%)	20 (6%)	378	4.2	Accepted

	environmental responsibility and long-term sustainability								
	Grand mean							4.2	

Source: Field Survey 2024

Table above shows the mean distribution of opinions of the respondents on how recycling initiatives affect sustainable development of Ebonyi State. The data showed that the majority of the respondents were all positive in their assertion. The mean of 4.2 depicts that respondents are all in agreement that Recycling reduces the need for raw materials, preserving natural resources like forests and minerals for future generations.

Table 2: Effect of Waste-To-Energy (Wte) on Sustainable Development of Ebonyi State

s/n	Item	VH	High	U	LE	VLE	Total	Mean	Decision
1	WtE reduces the volume of waste sent to landfills, decreasing land usage and minimizing environmental pollution in Ebonyi State.	120 (32%)	170 (45%)	20 (6%)	38 (10%)	30 (8%)	378	4.0	Accepted
2	Converts waste into electricity or heat, providing a renewable energy source that supports local energy needs and reduces reliance on fossil fuels.	150 (38%)	150 (38%)	20 (6%)	30 (8%)	18 (5%)	378	4.1	Accepted
3	WtE facilities often have advanced emission controls, helping to lower greenhouse gas emissions compared to traditional waste disposal methods	150 (38%)	138 (37%)	30 (8%)	30 (8%)	30 (8%)	378	4.0	Accepted
4	Enables the recovery of valuable materials and energy from waste, contributing to resource efficiency and supporting sustainable resource management.	170 (45%)	138 (37%)	20 (6%)	30 (8%)	40 (11%)	378	4.2	Accepted
5	Creates job opportunities in the WtE sector, including construction, operation, and maintenance, fostering economic development and enhancing community livelihoods.	140 (37%)	158 (42%)	10 (3%)	40 (11%)	40 (11%)	378	4.0	Accepted
	Grand mean							4.06	

Source: Field Survey 2024

Table above shows the mean distribution of opinions of the respondents on effect of Waste-to-Energy (WtE) on sustainable development of Ebonyi State. The grand mean of 4.06 is an indication that the respondents accepted that all the listed items.

Table 3: Effect of Material Recovery Facilities (MRFs) on sustainable development of Ebonyi State

s/n	Item	Very High	High	Undecided	Low Extent	Very Low Extent	Total	Mean	Decision
1	MRFs enhance the efficiency of sorting and processing recyclables, leading to higher recycling rates and reduced landfill waste.	140 (37%)	140 (37%)	20 (6%)	48 (13%)	30 (8%)	378	4.0	Accepted
2	By recovering valuable materials, MRFs reduce the need for virgin resources, conserving natural resources and promoting sustainability	150 (38%)	140 (37%)	10 (3%)	48 (13%)	20 (6%)	378	4.1	Accepted
3	Recycling materials through MRFs often requires less energy compared to producing new products, contributing to energy conservation efforts.	150 (38%)	120 (32%)	30 (8%)	40 (11%)	30 (8%)	378	4.1	Accepted
4	Proper sorting and processing of recyclables minimize contamination and environmental pollution, supporting cleaner air and water in Ebonyi State.	138 (37%)	160 (42%)	10 (3%)	60 (16%)	20 (6%)	378	4.0	Accepted
5	MRFs generate jobs in waste sorting, processing, and management, stimulating local economic development and providing employment opportunities in Ebonyi State.	138 (37%)	160 (42%)	10 (3%)	60 (16%)	20 (6%)	378	4.0	Accepted
	Grand Means							**4..94**	

Source: Field Survey 2024

Table above shows the mean distribution of opinions of the respondents on effect of Material Recovery Facilities (MRFs) on sustainable development of Ebonyi State. The grand mean sore of 4.04 revealed that the respondents accepted all the items listed in the table.

Test of Research Hypotheses

Data generated from the study were used to test the hypotheses using the chi-square test tool with formular as:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Where O = observed frequency

E = Expected frequency

Assumptions: Level of significance = 0.05

Decision rule: Reject Ho it the calculated value of χ^2 is greater than the critical value of χ^2 otherwise accept Ho.

Test of hypotheses one

Statement of hypothesis one

Ho: Recycling initiatives have no significant effect on the sustainable development of Ebonyi State.

Table 4: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	103.403(a)	16	.000
Likelihood Ratio	90.626	16	.000
Linear-by-Linear Association	9.602	1	.002
N of Valid Cases	280		

a 13 cells (52.0%) have expected count less than 5. The minimum expected count is .24.

SOURCE: SPSS Output version 23

D.F = Degree of freedom; D.F = 16; χ^2cal = 103.403, p = 0.05, d.f = 16 $\therefore \chi^2 = 26.30$

Result: The chi-square test showed that if calculated value is greater than the table value, then we reject the null hypothesis and accept the alternative hypothesis.

Decision: Since the calculated value of $\chi^{2\,=}$ 103.403 is greater than the table value of $\chi^{2\,=}$ 26.30 we therefore reject the null hypothesis and accept the alternative hypothesis. The statistical significance indicated that Recycling initiatives have a significant effect on the sustainable development of Ebonyi State.

Test of hypotheses Two

Statement of hypothesis Two

Ho: Waste-to-Energy (WtE) projects have no significant effect on the sustainable development of Ebonyi State

Table 5: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	190.310(a)	16	.000
Likelihood Ratio	125.398	16	.000
Linear-by-Linear Association	40.659	1	.000
N of Valid Cases	280		

a 8 cells (40.0%) have expected count less than 5. The minimum expected count is .47.

SOURCE: SPSS Output version 23

D.F = Degree of freedom; D.F = 16

χ^2cal = 190.310, p = 0.05, d.f = 16: $\chi^2 = 26.30$

Result: The chi-square test showed that if calculated value is greater than the table value, then we reject the null hypothesis and accept the alternative hypothesis.

Decision: Since the calculated value of $\chi^{2\,=}$ 190.310 is greater than the table value of $\chi^{2\,=}$ 26.30, we therefore reject the null hypothesis and accept the alternative hypothesis. The statistical significance indicated that Waste-to-Energy (WtE) projects have a significant effect on the sustainable development of Ebonyi State.

Test of hypotheses Three

Statement of hypothesis Three

Ho: Material Recovery Facilities (MRFs) have no significant effect on the sustainable development of Ebonyi State

Table 6: Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	208.236(a)	12	.000
Likelihood Ratio	152.495	12	.000
Linear-by-Linear Association	76.788	1	.000
N of Valid Cases	280		

a 9 cells (45.0%) have expected count less than 5. The minimum expected count is .34.
SOURCE: SPSS Output version 23

D.F = Degree of freedom
D.F = 16
χ^2cal = 208.236, p = 0.05, d.f = 16 $\therefore \chi^2 = 26.30$
Decision Rule: The decisions rule for χ^2 is that if the calculated value of χ^2 is less than the table value, then we accept the "null hypothesis" but if the calculated value is greater than table value we reject the null hypothesis.
Decision: Since the calculated value of $\chi^{2\,=}$ 208.236 is greater than the table value of $\chi^{2\,=}$ 26.30, we therefore reject the null hypothesis and accept the alternative hypothesis. The statistical significance indicated that Material Recovery Facilities (MRFs) have a significant effect on the sustainable development of Ebonyi State.

5. Discussion of Findings

The result of hypothesis one indicated that Recycling initiatives have a significant effect on the sustainable development of Ebonyi State. This is evident from the study that the value of $\chi^{2\,=}$ 103.403 is greater than the table value of $\chi^{2\,=}$ 26.30 we therefore reject the null hypothesis and accept the alternative hypothesis. The findings reveal that recycling initiatives substantially impact the sustainable development of Ebonyi State. By enhancing resource conservation, recycling reduces the demand for raw materials, preserving natural resources and promoting environmental sustainability. The energy savings associated with recycling processes further contribute to reducing carbon emissions and conserving energy, aligning with broader sustainability goals. Economically, recycling initiatives create job opportunities in collection, sorting, and processing sectors, stimulating local economic growth and supporting community livelihoods. Additionally, increased public awareness through recycling programs fosters a culture of environmental responsibility, encouraging sustainable practices among residents. Overall, the positive effects of recycling initiatives on resource efficiency, energy conservation, economic development, and environmental quality underscore their critical role in advancing sustainable development in Ebonyi State.

The result of hypothesis two indicated that Waste-to-Energy (WtE) projects have a significant effect on the sustainable development of Ebonyi State. This is evident from the value of $\chi^{2\,=}$ 190.310 which is greater than the table value of $\chi^{2\,=}$ 26.30. The findings indicate that Waste-to-Energy (WtE) projects significantly enhance the sustainable development of Ebonyi State. By converting waste into energy, WtE projects reduce landfill use, mitigating environmental pollution and conserving land. They provide a renewable energy source, contributing to energy security and reducing reliance on fossil fuels. Advanced WtE technologies often feature emission controls that help lower greenhouse gas emissions, supporting climate goals. Additionally, WtE projects promote resource recovery, enabling the extraction of valuable materials from waste. Economic benefits include job creation in construction and operational phases, fostering local economic growth. Overall, WtE projects

contribute to environmental sustainability, energy efficiency, and economic development, underscoring their importance in Ebonyi State's sustainable development strategy.

Lastly, the result of hypothesis three revealed that Material Recovery Facilities (MRFs) have a significant effect on the sustainable development of Ebonyi State. This is based on the fact that value of $\chi^{2=}$ 208.236 is greater than the table value of $\chi^{2=}$ 26.30. The findings show that Material Recovery Facilities (MRFs) play a crucial role in the sustainable development of Ebonyi State. MRFs enhance recycling efficiency by sorting and processing recyclables, which significantly reduces landfill waste and promotes resource conservation. This efficiency leads to substantial energy savings compared to the production of new materials. Additionally, MRFs help minimize environmental pollution by reducing contamination and improving waste management practices. The economic impact is also notable, as MRFs create job opportunities in waste management sectors, supporting local employment and economic growth. Overall, MRFs contribute to a more sustainable environment, energy conservation, and economic development, highlighting their significant role in advancing sustainable development in Ebonyi State.

6. Summary of Findings

i. The finding revealed that Recycling initiatives have a significant effect on the sustainable development of Ebonyi State.
ii. That Waste-to-Energy (WtE) projects have a significant effect on the sustainable development of Ebonyi State.
iii. It was revealed that Material Recovery Facilities (MRFs) have a significant effect on the sustainable development of Ebonyi State

Conclusion

In conclusion, effective waste management is pivotal to the sustainable development of Ebonyi State. Implementing innovative waste management strategies, including recycling initiatives, Waste-to-Energy (WtE) projects, and Material Recovery Facilities (MRFs), significantly enhances environmental sustainability, resource conservation, and economic growth. Recycling and WtE technologies reduce landfill use, conserve energy, and lower greenhouse gas emissions, while MRFs improve recycling efficiency and support local employment. Together, these strategies foster a cleaner environment, support energy sustainability, and stimulate economic development. Embracing and expanding these waste management practices will be crucial for Ebonyi State to achieve its sustainability goals and ensure long-term ecological and economic benefits.

Recommendations

Based on the findings, the following recommendations are made:

1. **Enhance Recycling Programs**: Expand and improve recycling infrastructure across Ebonyi State to increase material recovery rates. Invest in public education campaigns to raise awareness and encourage active participation in recycling initiatives, thus boosting overall environmental sustainability.
2. **Develop Waste-to-Energy Projects**: Initiate and support Waste-to-Energy (WtE) projects to convert waste into renewable energy. This will reduce landfill dependency, decrease greenhouse gas emissions, and provide a sustainable energy source, aligning with long-term environmental and economic goals.
3. **Strengthen Material Recovery Facilities**: Upgrade and expand Material Recovery Facilities (MRFs) to improve waste sorting and processing efficiency. Enhance technological capabilities to ensure higher quality recyclable materials, contributing to reduced pollution and fostering local economic growth through job creation.

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