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EVALUATION OF SUSTAINABLE WAIST MANAGEMENT STRATEGIES TO REDUCE PLASTIC POLLUTION IN DIOBE PORT HARCOURT RIVERS STATE

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Abstract
This study evaluated sustainable waste management strategies for reducing plastic pollution in Diobu, Port Harcourt, Rivers State. The research adopted a mixed-methods design, integrating both quantitative and qualitative approaches to obtain comprehensive insights into plastic waste generation, disposal practices, public awareness, and institutional challenges within the study area. Data were collected through structured questionnaires administered to residents and traders, as well as semi-structured interviews conducted with informal waste collectors and officials of the Rivers State Waste Management Agency (RIWAMA). Findings revealed high consumption of single-use plastics such as sachet water bags, polyethylene packaging, and plastic bottles, alongside limited waste segregation and low recycling rates. Indiscriminate dumping and open burning were identified as common disposal methods, contributing to clogged drainage systems, urban flooding, environmental degradation, and increased health risks. Although some informal recycling activities exist, they operate without formal support or structured integration into the municipal waste system. Major barriers to sustainable plastic waste management include inadequate infrastructure, weak policy enforcement, limited public awareness, and financial constraints. The study concludes that effective reduction of plastic pollution in Diobu requires a multi-stakeholder approach anchored on the 3Rs (Reduce, Reuse, Recycle), community-based waste segregation, integration of informal waste actors, enforcement of environmental regulations, and adoption of circular economy models. The research provides practical recommendations aimed at promoting environmentally sound, economically viable, and socially inclusive waste management practices in urban Nigeria.

Keywords: ***Sustainable Waste Management; Plastic Pollution; Circular Economy; Environmental Health***

INTRODUCTION

Background to the Study

Plastic pollution has emerged as a critical environmental concern globally and is especially severe in rapidly urbanizing regions like Nigeria. The increasing reliance on single-use plastics, coupled with inadequate waste management infrastructure, has led to the accumulation of plastic waste in urban centers, water bodies, and drainage systems, resulting in significant environmental degradation, health risks, and economic losses (Dumbili & Henderson, 2020). In Nigeria, it is estimated that over 60 million plastic sachets and bags are discarded daily, most of which end up clogging urban drainage systems or contributing to marine litter (Henderson & Dumbili, 2020).

Diobu, a densely populated and commercially vibrant area in Port Harcourt, exemplifies the challenges associated with plastic waste. Like many other urban neighborhoods in Nigeria, Diobu lacks an integrated and sustainable waste management system. Waste collection is often irregular, informal recycling is poorly coordinated, and public awareness on waste segregation and plastic pollution remains low. This has led to indiscriminate dumping, especially of plastic materials such as sachet water bags, polyethylene wrappers, and plastic bottles, which are non-biodegradable and environmentally persistent.

Research shows that poor waste disposal habits and a lack of effective legislation are primary contributors to Nigeria's plastic waste crisis (Ejim & Eze, 2021). Furthermore, only a small fraction

(less than 12%) of generated plastic waste in Nigerian cities is recycled annually, while the rest ends up in landfills or open environments, leading to health and environmental hazards (Nyakuma & Ivase, 2021).
The environmental consequences of plastic pollution include blocked drainage systems leading to urban flooding, contamination of soil and water resources, and threats to aquatic life and biodiversity. In addition, plastics may release toxic substances when exposed to sunlight or improperly burned, leading to health risks among urban populations (Kehinde et al., 2020).

Sustainable waste management strategies offer a path forward. These include the promotion of the 3Rs (Reduce, Reuse, Recycle), the development of circular economy models, and investment in innovative recycling technologies. Public-private partnerships, environmental education, and community-based waste segregation programs have shown promise in other Nigerian cities and could be adapted for Diobu (Olaoti, 2024).
This study aims to investigate sustainable waste management strategies that can effectively reduce plastic pollution in Diobu, Port Harcourt. It seeks to bridge knowledge gaps and provide practical solutions that are socially inclusive, economically viable, and environmentally sound.

Statement of the Problem
Plastic pollution has become one of the most pressing environmental challenges of the 21st century, particularly in developing countries like Nigeria, where urbanization has outpaced the development of adequate waste management infrastructure. In recent years, plastic waste has increasingly filled up open spaces, blocked drainage systems, polluted water bodies, and contributed to urban flooding, posing grave threats to human health and ecosystem stability. Despite efforts to improve solid waste management, plastic waste especially single-use plastics such as sachet water bags, food wrappers, and disposable containers remains a persistent and growing problem in urban areas. In Port Harcourt, the capital of Rivers State and one of Nigeria's most industrialized cities, this issue is particularly severe. The suburb of Diobu, known for its high population density and informal commercial activities, exemplifies the waste management crisis in urban Nigeria. Waste disposal practices in Diobu are predominantly informal, with limited government intervention in collection, recycling, or environmental enforcement. Households, street vendors, and markets generate significant volumes of plastic waste daily, most of which are either burned openly releasing toxic fumes or indiscriminately dumped into gutters, streets, and unregulated dumpsites. These practices lead to clogged drains, increased risk of flooding during the rainy season, and the degradation of urban aesthetics and public health.
Several factors contribute to this problem. First, there is an evident lack of sustainable waste management systems, including inadequate infrastructure for waste separation, collection, and recycling. Public bins are scarce, and where available, they are poorly maintained or underutilized. Secondly, there is low awareness and participation in environmentally responsible behavior among residents. Many people lack knowledge about the environmental consequences of plastic pollution and the economic potential of recycling. Thirdly, existing policies and regulations on plastic waste management are either weak, poorly implemented, or entirely absent at the local level. For example, despite the passage of the Plastic Bag Prohibition Bill in Nigeria, enforcement mechanisms are virtually non-existent in many urban communities like Diobu.
Furthermore, informal waste pickers, who form the backbone of recycling activities in Nigeria, operate without institutional support, safety guidelines, or integration into formal waste management systems. As a result, valuable recyclable plastic materials are lost, while hazardous waste accumulates in residential environments. This fragmented approach undermines the prospects of achieving sustainable waste management and the objectives of Nigeria's national environmental policies.
Numerous studies have confirmed that plastic pollution in Nigerian cities not only disrupts ecological balance but also results in substantial economic costs, such as loss of tourism potential, public health

expenses, and flood-related infrastructure damage (Kehinde et al., 2020; Dumbili & Henderson, 2020). Yet, while cities like Lagos have piloted programs to reduce single-use plastics and improve recycling, smaller urban zones like Diobu remain largely underserved and understudied. There is a wide research and policy gap regarding scalable, community-based waste management strategies that can be tailored to the unique socio-economic and environmental context of Diobu.

Thus, this study is necessary to explore sustainable waste management strategies such as waste segregation at source, community recycling initiatives, public education, and circular economy models that could significantly reduce plastic pollution in Diobu. Without timely and strategic intervention, the cumulative effects of plastic waste in this area could escalate into an environmental and public health emergency, undermining the broader goals of sustainable urban development.

Aim and Objectives of the Study

The aim of this study is to evaluate- sustainable waste management strategies that can effectively reduce plastic pollution in Diobu, Port Harcourt. To achieve this aim, the study pursued the following specific objectives, and they to:

1. examine the current state of plastic pollution in Diobu, Port Harcourt.
2. assess the existing plastic waste management practices in the area, including methods of collection, disposal and recycling
3. investigate the environmental and health impacts associated with poor plastic waste management in the study area.
4. evaluate public awareness, attitudes, and behaviors regarding plastic waste, recycling, and environmental responsibility.
5. identify barriers to sustainable plastic waste management, including infrastructural, regulatory, financial, and cultural factors.
6. propose practical, community-based strategies for reducing plastic pollution

Research Questions

In line with the aim and objectives of the study, the following research questions was formulated to guide the investigation:

- What is the current state of plastic pollution in Diobu, Port Harcourt?
- What plastic waste management practices are currently being used in the area?
- What are the environmental and public health impacts of poor plastic waste disposal in Diobu?
- What is the level of public awareness, perception, and behavioral response to plastic pollution and sustainable waste practices?
- What are the main barriers to achieving sustainable plastic waste management in Diobu?
- What sustainable waste management strategies can be implemented to reduce plastic pollution in the area?

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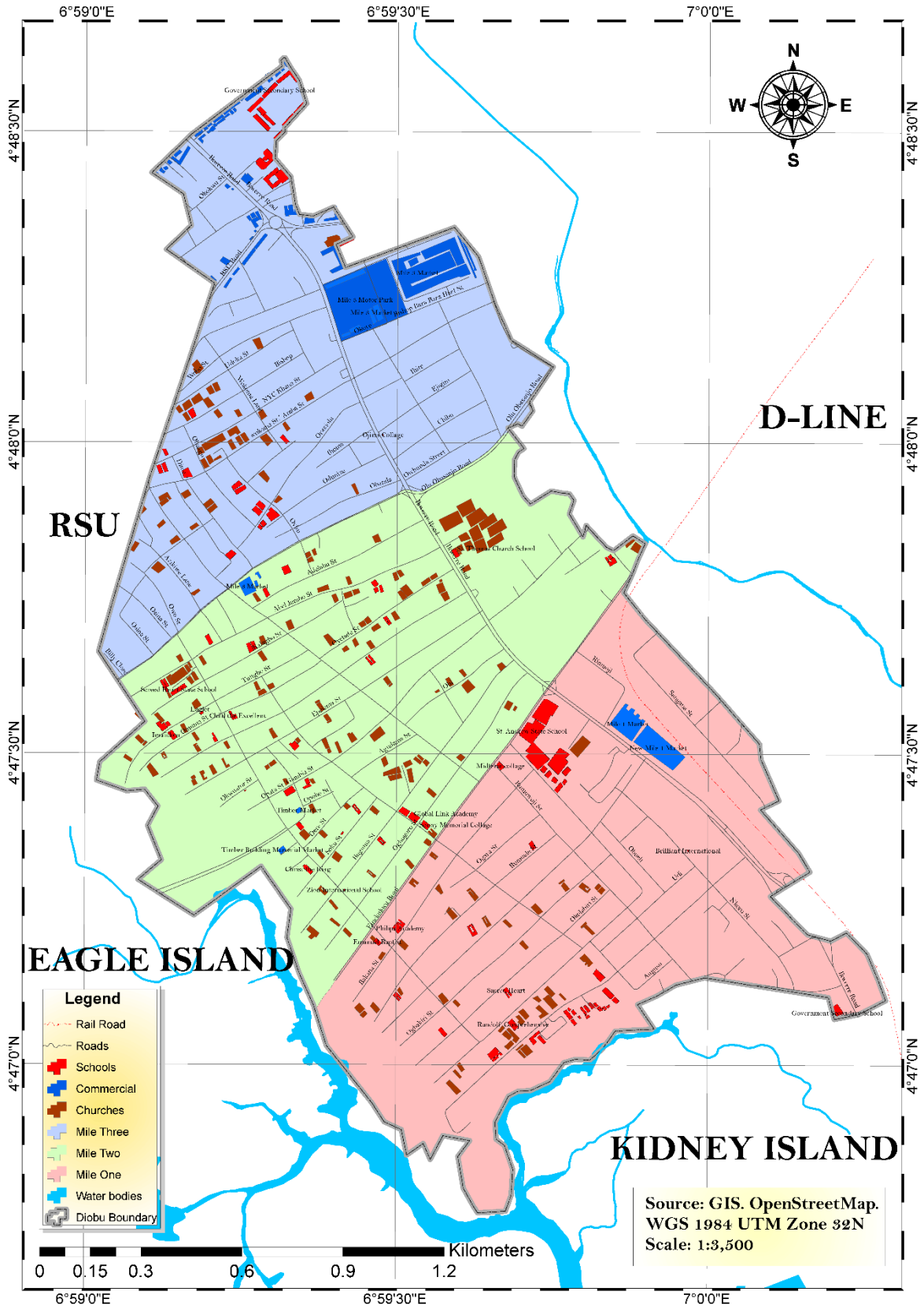

LITERATURE REVIEW

Conceptual Framework

Waste management is a critical environmental function that involves the collection, transportation, processing, recycling, and final disposal of waste materials. In the context of urban development and sustainability, effective waste management systems are central to achieving clean, safe, and livable environments. The World Health Organization (WHO) broadly defines waste as "something which the owner no longer wants at a given time and space, and which has no current or perceived market value" (Ogbonna, Ekweozor, &Igwe, 2002). However, this definition is constantly evolving as advances in recycling and resource recovery now allow many previously "valueless" materials such as plastic waste to be reintegrated into the production cycle.

In developing nations like Nigeria, waste management is far more than just an environmental necessity; it is a public health, economic, and governance issue. According to (Coker, 2018), waste generation in Nigerian urban areas has escalated due to population growth, urbanization, industrialization, and changing consumption patterns. Waste is generated from multiple sources including households, markets, institutions, and commercial activities, and comprises a mixture of biodegradable (organic) and non-biodegradable materials of which plastic waste is a significant and growing portion.

Urban centers such as Port Harcourt face acute challenges in managing municipal solid waste, often due to fragmented institutional arrangements, limited infrastructure, poor funding, and lack of technical capacity (Abdu et al., 2019). A striking indicator of inefficiency is the visible presence of waste heaps in public spaces, roadsides, and drainages, leading to environmental degradation, blocked waterways, and disease outbreaks. According to Donatus and Nwodeh, (2022), despite numerous reforms and the establishment of state and municipal waste management agencies, implementation remains weak and enforcement of environmental laws is inconsistent.

The concept of modern waste management transcends basic disposal; it is now embedded in the larger framework of sustainable development. Globally, sustainable waste management emphasizes principles such as the waste hierarchy which prioritizes prevention, minimization, reuse, recycling, energy recovery, and, as a last resort, disposal. Additionally, concepts like zero waste, circular economy, and extended producer responsibility (EPR) have gained traction as more holistic approaches to reduce environmental footprint.

In Nigeria, however, waste management remains heavily reliant on traditional and unsustainable methods such as open dumping, open burning, and landfilling without proper containment measures. These practices have been widely criticized for their adverse impacts on human health and the environment, including air and groundwater pollution, greenhouse gas emissions, and habitat destruction (Omole, Isiorho, &Ndambuki, 2016).

Furthermore, the role of informal waste workers also known as scavengers or waste pickers is central to the waste management system in Nigeria. While largely unregulated, this sector contributes significantly to the recovery and recycling of materials, especially plastics, metals, and glass. Integrating these informal actors into formal waste management systems could greatly enhance overall efficiency and sustainability.

Definitions of Waste and Waste Management

Definition of Waste: The term waste broadly refers to any material that is discarded after primary use or is considered of no further use by the owner. The United Nations Environment Programme (UNEP) defines waste as "substances or objects which are disposed of or are intended to be disposed of, or are required to be disposed of by the provisions of national law." Similarly, the European Union Waste Framework Directive (2008/98/EC) characterizes waste as "any substance or object which the holder discards or intends or is required to discard."

In environmental discourse, waste is not only about unwanted materials but also includes resources that are improperly managed. As such, definitions of waste have evolved from viewing it as an end-

of-life burden to considering it a resource with economic potential when properly handled especially within the frameworks of recycling, circular economy, and sustainable development.
In the Nigerian context, waste is typically classified into:

- Municipal Solid Waste (MSW): household and commercial waste,
- Industrial Waste: generated by manufacturing processes,
- Hazardous Waste: chemical, medical, or toxic materials, and
- Plastic Waste: predominantly single-use items such as sachet water bags, bottles, and packaging.

Given the focus of this study, plastic waste is a critical subset of MSW due to its non-biodegradability, visibility in urban spaces, and environmental impact.
Definition of Waste Management: Waste management refers to the systematic collection, transportation, treatment, and disposal of waste to minimize its negative impacts on human health and the environment. According to the United States Environmental Protection Agency (EPA), waste management includes not only the treatment and disposal of waste but also the processes involved in waste prevention, reduction, recycling, and recovery.
Modern waste management has expanded to include:

- Source reduction (reducing waste at the point of generation),
- Material recovery (recycling and composting),
- Energy recovery (converting waste to energy), and
- Safe disposal (landfilling and incineration with controls).

In Nigeria, waste management is governed at multiple levels federal, state, and local but faces systemic issues such as poor infrastructure, lack of funding, weak enforcement, and low public awareness. In urban areas like Diobu, Port Harcourt, informal waste systems dominate, with scavengers playing a key role in plastic waste recovery despite lacking formal support or protection.

Evolution from Traditional to Sustainable Waste Practices
The management of waste has undergone significant transformation over the last few decades, evolving from rudimentary collection and disposal systems to complex, integrated frameworks centered on sustainability, resource efficiency, and environmental protection. This transition reflects growing global concern over climate change, pollution, resource depletion, and public health, especially in urbanizing nations like Nigeria where population growth and consumption patterns have outpaced infrastructural development.

Traditional Waste Practices
Historically, traditional waste management practices were largely reactive, linear, and disposal-focused. Waste was typically collected from households and business premises and transported to open dumps or rudimentary landfills, often located on the outskirts of towns. In rural and pre-industrial societies, where waste was primarily organic, these practices posed minimal environmental risks due to the biodegradable nature of the materials. However, as societies industrialized and urbanized, waste streams became more complex, diverse, and hazardous comprising plastics, electronic components, synthetic chemicals, and non-degradable packaging.
In many parts of Nigeria, including Port Harcourt, waste collection remains irregular, unsegregated, and poorly monitored. Open dumping and open-air incineration are still widely practiced due to limited access to engineered landfills or waste treatment technologies. Such traditional methods lead to severe environmental degradation, including water contamination, air pollution, and urban flooding due to blocked drainages.
These methods are not only inefficient but also environmentally unsustainable. The absence of source segregation, reliance on manual labor, and neglect of recycling opportunities characterize the shortcomings of traditional systems. Moreover, these practices often ignore the value of waste as a secondary resource and overlook the economic potential embedded in recyclable materials such as plastics, glass, and metals.

Emergence of Sustainable Waste Practices

In contrast to traditional systems, sustainable waste management practices are grounded in the principles of waste minimization, environmental protection, and resource recovery. Sustainability in waste management refers to the design and execution of systems that reduce waste generation, promote recycling and reuse, and ensure the safe disposal of residual waste all while protecting human health and minimizing environmental impact.

i. **The paradigm shift toward sustainable waste management has been driven by:**
   - The waste hierarchy model, which ranks waste handling methods from most to least desirable: prevention, minimization, reuse, recycling, energy recovery, and final disposal.
   - Environmental legislation and international agreements, such as the Basel Convention, which advocate for better transboundary waste movement and sound environmental practices.
   - The global push toward achieving the United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action).

ii. **Sustainable practices include:**
   - Waste segregation at source, which improves the efficiency of recycling and composting.
   - Recycling and upcycling, which transform waste into new products or materials of higher value.
   - Composting, which allows organic waste to be converted into agricultural inputs.
   - Circular economy models, which emphasize keeping materials in use and designing out waste entirely.

Countries with advanced waste systems have also embraced technological innovations, such as waste-to-energy plants, smart bins with sensors, and digital waste tracking platforms.

Nigeria's Position in the Evolution

Although Nigeria has begun adopting elements of sustainable waste management, progress is uneven and largely confined to specific cities or private-sector initiatives. Lagos, for example, has piloted waste recycling hubs, plastic buy-back centers, and private-sector participation through the Lagos Waste Management Authority (LAWMA). In Port Harcourt, however, these developments are less visible, and neighborhoods like Diobu continue to suffer from outdated waste practices dominated by informal actors.

A key barrier to this transition is the lack of political will, public awareness, and infrastructure. For sustainable practices to flourish in cities like Port Harcourt, there must be intentional investment in community education, policy reform, and stakeholder partnerships. Integration of informal waste pickers, who already play a crucial role in plastic recovery, into formal systems is also essential for inclusive and sustainable outcomes.

Overview of Municipal Solid Waste in Nigeria

Municipal Solid Waste (MSW) refers to waste materials generated in residential, commercial, institutional, and public areas within urban settings. It typically includes organic waste, paper, plastics, textiles, metals, glass, and other everyday refuse. In developing countries like Nigeria, MSW also often contains significant amounts of construction debris, electronic waste, and sometimes hazardous components due to improper segregation and disposal.

Volume and Composition of Waste

Nigeria, with a population of over 220 million people and a rapidly urbanizing landscape, generates an estimated 32 million tonnes of solid waste annually, making it one of the largest producers of MSW in Africa (Babayemi et al., 2018). The daily per capita waste generation rate varies from 0.44 to 0.66 kg, depending on socioeconomic status, region, and urbanization level.

The composition of MSW in Nigeria is heterogeneous and typically includes:

- Organic waste (40–60%): food scraps, agricultural residues, and garden waste

- Plastics (10–20%): single-use bags, bottles, sachet water packs
- Paper (5–10%): cartons, newspapers, packaging
- Metals, glass, textiles, and inorganic components (less than 10%)

Notably, plastic waste has seen a sharp rise in urban areas, driven by increased consumption of packaged food and water, lack of alternatives to plastic packaging, and widespread use of non-biodegradable materials. This trend is particularly visible in high-density neighborhoods like Diobu, Port Harcourt, where sachet water bags and disposable food containers dominate the streets and drainage systems.

Waste Collection and Management Systems

Waste management in Nigeria is largely decentralized, with responsibilities assigned to state and local government authorities. However, these bodies often lack the resources, technical capacity, and logistical infrastructure to manage waste effectively. According to Adama (2018), only about 30% of urban solid waste is collected regularly, and an even smaller fraction is processed or recycled. The rest ends up in illegal dumpsites, waterways, or is openly burned.

In Port Harcourt, the Rivers State Waste Management Agency (RIWAMA) is tasked with coordinating waste collection and disposal. However, in practice, coverage is limited, and informal settlements like Diobu rely heavily on self-disposal, informal collectors, or unregulated dumping. There is minimal to no segregation at source, and households commonly mix organic, recyclable, and hazardous waste in the same containers or plastic bags.

Moreover, most municipalities still depend on open dumping as the primary method of waste disposal. Engineered sanitary landfills are rare, and where they exist, they are often poorly maintained. This poses severe environmental and health risks, including groundwater contamination, disease outbreaks, and methane emissions.

Role of the Informal Sector

One of the most significant yet underappreciated actors in Nigeria's MSW system is the informal waste sector, which includes scavengers, waste pickers, and small-scale recyclers. These individuals manually sort waste materials from dumpsites, roadsides, or household bins and sell valuable recyclables especially plastics, aluminum cans, and metals to middlemen or recycling firms.

While this sector provides critical waste recovery services and employment for thousands of Nigerians, it is characterized by:

- Poor working conditions
- Lack of protective equipment
- No formal recognition or regulation
- Exposure to hazardous waste

Formal integration of the informal sector remains limited, despite increasing evidence of its potential to contribute to sustainable urban waste management and resource recovery.

Challenges in MSW Management

Key challenges facing MSW management in Nigeria include:

- Inadequate infrastructure (e.g., bins, trucks, waste transfer stations)
- Irregular and insufficient funding from local authorities
- Low public awareness and participation
- Weak legal and institutional frameworks
- Poor data collection and planning

These challenges are amplified in densely populated and low-income areas like Diobu, where infrastructural neglect, weak policy enforcement, and high consumption of low-value plastics create a waste management crisis.

Relevance of Waste Management in Urban Environmental Health

Proper waste management is a cornerstone of urban environmental health. In densely populated and rapidly urbanizing areas such as Diobu in Port Harcourt inefficient or absent waste systems can directly threaten the well-being of residents, damage natural ecosystems, and undermine economic development. The interconnections between waste, environment, and public health make the issue not merely an environmental concern but also a developmental, social, and human rights challenge.

Health Implications of Poor Waste Management

Poorly managed municipal solid waste (MSW) exposes urban populations to a range of health hazards. Open dumps, which are common in Nigerian cities, serve as breeding grounds for disease vectors such as mosquitoes, flies, and rodents, increasing the risk of communicable diseases like malaria, cholera, and typhoid fever. Uncollected or improperly disposed waste blocks drainage systems, leading to flooding during rainfall, which in turn spreads waterborne pathogens and heightens vulnerability to outbreaks.

Additionally, the open burning of waste, including plastic, releases toxic gases such as dioxins, furans, and particulate matter. These emissions have been linked to respiratory diseases, cancers, cardiovascular conditions, and long-term neurological damage. Vulnerable groups such as children, pregnant women, and the elderly are particularly at risk.

Informal waste workers who scavenge without protective gear face daily exposure to biohazards, sharp materials, and toxic chemicals. Studies have shown high incidences of skin infections, respiratory issues, and injuries among waste pickers in Nigerian cities (Afon, 2012).

Environmental Impacts in Urban Areas

Environmental degradation caused by unmanaged waste is especially pronounced in urban slums and informal settlements. Littered plastics clog drainage systems, leading to stagnant water, urban flooding, and the destruction of public infrastructure. In Port Harcourt, recurring floods have been partly attributed to blocked drains filled with plastic and organic waste. These floods not only disrupt economic activity but also displace residents and contaminate surface and groundwater sources.

Improper landfilling and leachate seepage pollute soil and underground aquifers, diminishing the quality of drinking water and damaging agricultural potential. In coastal cities, plastic waste often ends up in rivers and eventually the ocean, contributing to marine pollution and threatening aquatic biodiversity. Diobu's proximity to natural waterways increases the likelihood of such environmental transmission paths.

Socio-Economic Consequences

The failure to manage waste sustainably also has broader socio-economic consequences. Poor waste conditions:

- Lower the aesthetic and real estate value of urban neighborhoods
- Discourage tourism and commercial investment
- Place economic burdens on public health systems due to disease outbreaks
- Lead to school absenteeism and productivity loss due to health-related issues

Furthermore, failing to harness the economic potential of recyclable waste materials means lost opportunities for employment, entrepreneurship, and revenue generation. A well-structured waste management system could create thousands of green jobs, particularly for low-income youth and women, if supported through micro-enterprises, cooperatives, and government incentives.

Importance in Achieving Sustainable Development Goals (SDGs)

Waste management intersects with multiple SDGs, including:

- SDG 3 (Good Health and Well-being) – through reduction of waste-related illnesses
- SDG 6 (Clean Water and Sanitation) – by preventing pollution of water sources
- SDG 11 (Sustainable Cities and Communities) – by making cities inclusive, safe, and resilient

- SDG 12 (Responsible Consumption and Production) – through promoting waste minimization and resource efficiency
- SDG 13 (Climate Action) – by reducing greenhouse gas emissions from landfills and incineration

Plastic Pollution, Sources, Effects, and Trends

Plastic waste is a major component of municipal solid waste in urban Nigeria, and understanding its sources is essential for developing targeted and effective waste management strategies. The primary sources of plastic waste are broadly categorized into domestic, commercial, and industrial sectors. Each category contributes distinct types and volumes of plastic waste to the urban environment, particularly in high-density and low-income areas such as Diobu, Port Harcourt.

Main Sources of Plastic Waste (Domestic, Commercial, Industrial)

Plastic waste is generated from a wide range of human activities and industrial processes, particularly in urban environments where consumption and population density are high. In Nigeria, the proliferation of single-use plastic products, coupled with poor waste handling systems, has led to a significant accumulation of plastic materials in the environment. These wastes originate primarily from three key sectors: domestic (households), commercial (markets and services), and industrial (manufacturing and packaging).

Domestic Sources

Households are one of the largest contributors to plastic waste in Nigeria. The widespread use of inexpensive, disposable plastic products has become a defining feature of daily life, especially in low- and middle-income urban neighborhoods like Diobu in Port Harcourt. Common plastic waste items generated in homes include:

- Sachet water bags (commonly known as "pure water")
- Plastic bottles from soft drinks and water
- Polyethylene shopping bags
- Food wrappers and takeaway containers
- Toiletry and detergent packaging

The convenience and affordability of single-use plastics, coupled with limited environmental awareness and the absence of alternatives, make domestic waste a primary source of plastic pollution. In most cases, these items are disposed of indiscriminately on roadsides, in drains, or in open spaces due to the absence of public bins and structured household waste collection systems.

Commercial Sources

Commercial establishments, including open markets, retail shops, eateries, hotels, and transportation hubs, generate large volumes of plastic waste daily. This category is characterized by:

- Plastic packaging waste from food items, consumer goods, and shipping materials
- Disposable utensils and plates from street food vendors and restaurants
- Plastic carrier bags used for customer purchases
- Stretch film and bubble wrap from warehousing and distribution activities

In marketplaces across Port Harcourt, for instance, traders extensively use plastic bags to package both perishable and non-perishable items. Due to the lack of enforcement of plastic bag bans and the affordability of these materials, there is little motivation to transition to eco-friendly alternatives. Moreover, many commercial centers do not have centralized waste collection services or guidelines for separating plastics from organic waste. As a result, plastic waste is often mixed with other refuse, making recycling more difficult and increasing the likelihood of environmental leakage.

Industrial Sources

Industries play a significant role in both the production and disposal of plastic waste. This includes:

- Manufacturing residues, such as defective products, off-cuts, or trimming waste from plastic molding and packaging factories
- Packaging waste from raw materials or finished goods
- Discarded plastic containers used in chemical, pharmaceutical, and food processing industries

In industrial hubs across Nigeria, including parts of Port Harcourt, plastic waste is often generated in large volumes but is poorly regulated. Many small and medium-sized enterprises (SMEs) lack in-house recycling programs and rely on external contractors who may not adhere to environmentally sound disposal methods.

Furthermore, the absence of national-level enforcement of Extended Producer Responsibility (EPR) means that most industries are not held accountable for the end-of-life management of the plastic products they introduce into the market. This leads to a linear production-disposal model, where plastics flow from manufacturers to consumers and ultimately into the environment without recovery or reuse.

Environmental, Health, and Socio-Economic Effects of Plastic Pollution

Plastic pollution has emerged as a serious and persistent threat to environmental quality, public health, and urban economic development. In Nigeria, where plastic waste management remains largely informal and reactive, its effects are magnified in densely populated, infrastructure-deficient communities such as Diobu in Port Harcourt. These effects can be classified into environmental, health-related, and socio-economic dimensions, each of which contributes to the urgency for sustainable intervention.

Environmental Effects

i. **Clogged Drainage and Urban Flooding**

One of the most visible consequences of plastic pollution in Nigerian cities is the blockage of stormwater drainage systems. Non-biodegradable plastics such as sachet water bags, plastic bottles, and shopping bags frequently accumulate in gutters and culverts, leading to flooding during the rainy season. In Port Harcourt, seasonal flooding is often linked to such blockages, which also cause road damage, erosion, and disruption of daily activities.

ii. Soil and Water Contamination

Plastics that leach chemicals like phthalates, bisphenol A (BPA), and polybrominated flame retardants contaminate both soil and groundwater. These substances are persistent organic pollutants that can interfere with soil health and agricultural productivity. Open dumping of plastics in residential areas or near farms poses a long-term threat to food safety and water quality (Adedokun et al., 2024).

iii. Degradation of Aquatic and Terrestrial Ecosystems

Plastic waste discharged into rivers, such as the Bonny and New Calabar Rivers near Port Harcourt, contributes to marine and freshwater pollution. Microplastics have been detected in aquatic organisms, affecting biodiversity and the food web. On land, plastic debris also disrupts habitats for urban wildlife and contributes to visual blight, reducing the aesthetic value of public spaces.

Public Health Effects

i. Disease Vectors and Epidemics

Stagnant water caused by clogged drains creates breeding grounds for mosquitoes, which spread malaria and dengue fever. Rodents and flies, which thrive around waste heaps, contribute to the transmission of cholera, typhoid, and Lassa fever, particularly in underserved communities like Diobu where access to clean water and healthcare may be limited.

ii. Toxic Emissions from Open Burning

Due to the absence of formal disposal infrastructure, residents often burn plastic waste in open spaces. This practice releases harmful substances, including dioxins, furans, and polycyclic aromatic hydrocarbons (PAHs), which are associated with respiratory illness, skin disorders, hormonal disruption, and even cancer. Children, pregnant women, and elderly individuals are especially vulnerable (Kehinde et al., 2020).

iii. Microplastics in Food and Water

Research shows that plastic fragments have entered Nigeria's aquatic food chain, particularly in fish consumed by urban residents (Dada & Bello, 2023). These microplastics can absorb and transport toxic chemicals, posing long-term health risks to consumers. The lack of regulation on food safety standards for microplastic contamination exacerbates this invisible public health crisis.

Socio-Economic Effects

i. Economic Burden on Urban Management

Plastic pollution imposes a financial strain on local governments, which must allocate resources for waste collection, drain clearing, flood control, and public health responses. In cities like Port Harcourt, such expenses often compete with other essential services like education and infrastructure.

ii. Reduced Livability and Investment

Poor waste management and plastic pollution degrade the quality of urban life and reduce the attractiveness of neighborhoods for residential and commercial investment. Informal settlements like Diobu suffer from low property values, infrastructural decay, and reduced access to services, which discourages formal economic development.

iii. **Lost Resource and Employment Opportunities**

Plastic waste, when unmanaged, represents a lost opportunity for resource recovery and job creation. If efficiently collected and recycled, plastics could feed into a circular economy, supporting small-scale recycling businesses and providing income to thousands of informal waste workers. However, the current system in Nigeria lacks the infrastructure and policy support to convert plastic waste into economic value (Ejim & Eze, 2021).

Sustainable Waste Management Strategies (3rs, circular economy, etc.)

In response to the global plastic pollution crisis, the transition from traditional linear waste systems ("take, make, dispose") to sustainable waste management strategies is increasingly being adopted. These strategies emphasize the conservation of resources, reduction of environmental harm, and creation of economic value from waste. Among the most prominent approaches are the 3Rs (Reduce, Reuse, Recycle) and the broader circular economy model. These concepts are gaining traction in Nigeria, although implementation remains limited by structural, financial, and institutional barriers.

Explanation of the 3Rs (Reduce, Reuse, Recycle)

The 3Rs framework Reduce, Reuse, Recycle is a globally recognized waste management hierarchy that promotes the minimization of waste generation and encourages environmentally responsible resource use. It serves as a foundational strategy in achieving sustainable plastic waste management and is particularly relevant for developing countries like Nigeria, where waste disposal systems are often inadequate, and environmental degradation from plastic pollution is severe.

i. Reduce

Reduction is the most effective strategy in the 3Rs hierarchy as it prevents the generation of waste at the source. It involves modifying production and consumption patterns to use fewer materials, especially non-biodegradable plastics. Reducing plastic usage directly minimizes the burden on waste collection, treatment, and disposal systems.

In Nigeria, this approach is crucial given the country's heavy reliance on single-use plastics, such as sachet water bags, disposable food containers, and polyethylene packaging. Efforts to reduce plastic waste may include:

- Consumer behavior change through awareness campaigns encouraging alternatives like reusable water bottles and cloth bags.
- Legislation and bans on non-essential single-use plastics.
- Product redesign to use less plastic or switch to biodegradable materials.

For example, Lagos State has attempted to restrict the distribution of plastic carrier bags in some markets and promote packaging alternatives, although enforcement remains weak [(Allen-Taylor, 2022)].

ii. Reuse

Reusing involves extending the life cycle of plastic products by using them multiple times before disposal. It reduces demand for new plastic items, cuts resource consumption, and delays entry into the waste stream.

Typical examples include:

- Refilling plastic water and beverage bottles.
- Reusing durable containers for storage and distribution.
- Implementing return systems for plastic crates, drums, and packaging in commercial settings.

In many Nigerian households and markets, informal reuse of plastic containers is already common, though mostly out of necessity. Scaling this into a structured reuse economy would require incentives for producers and consumers, such as deposit-refund schemes or discounts for returned packaging.

The challenge lies in ensuring that reused plastics, particularly for food and beverages, meet health and safety standards a significant gap in Nigeria's current regulatory framework.

iii. Recycle

Recycling is the process of converting plastic waste into new products, thereby conserving raw materials, saving energy, and reducing pollution. It is the most technically demanding of the 3Rs but also presents opportunities for economic growth and job creation.

There are two main forms of recycling in Nigeria:

- Formal recycling, conducted by licensed companies using mechanical processes to produce plastic pellets or new plastic items.
- Informal recycling, carried out by waste pickers and small entrepreneurs who collect, sort, and resell plastic waste to processors.

According to Ezeudu et al. (2024), Nigeria recycles less than 12% of its plastic waste, largely due to poor collection infrastructure, low public participation, and inadequate investment in recycling facilities [(Ezeudu et al., 2024)].

To boost recycling rates, Nigeria must:

- Establish source separation systems to improve material quality.
- Support plastic buy-back centers and cooperatives.
- Introduce financial incentives, such as subsidies or tax breaks for recyclers.
- Enforce Extended Producer Responsibility (EPR) policies requiring companies to finance the end-of-life management of their plastic products.

Application of Circular Economy Models

The circular economy (CE) model is a regenerative system that aims to eliminate waste and promote the continual use of resources. Unlike the traditional linear economy model of "take make dispose," the CE seeks to close material loops through reuse, repair, recycling, remanufacturing, and waste-to-resource transformation. Its application in plastic waste management offers a pathway to

environmental sustainability, economic inclusion, and climate resilience, particularly in countries like Nigeria facing mounting plastic pollution and waste management gaps.

Conceptual Foundation of Circular Economy in Waste Management

In the context of plastic waste, the circular economy promotes:

- Designing plastics for recyclability and durability
- Using recycled content in new plastic production
- Extending the life of plastic materials through reuse and remanufacturing
- Recovering value from waste via energy generation or material recovery

Globally, circular plastic strategies have reduced raw material dependency and improved environmental performance in many developed countries. In Nigeria, however, implementation is still at an early stage, with most progress occurring through pilot projects, informal sector innovation, and private enterprise initiatives (Ezeudu et al., 2024).

Circular Economy Applications in Nigeria

Recent studies and initiatives highlight growing CE adoption across Nigeria's plastic value chain:

i. Plastic Waste Recovery and Upcycling

In cities like Lagos and Abuja, companies and community-led programs are collecting used plastic and converting them into:

- Interlocking paving stones
- Furniture and building materials
- Textiles and composites

This represents a shift from linear disposal to resource regeneration. Small-scale processors play a key role here, albeit without consistent policy or financial support (Ikelle et al., 2023).

ii. Circular Product Design and Reverse Logistics

Some Nigerian producers have begun to incorporate recyclable packaging and return schemes into their supply chains. Examples include:

- Closed-loop systems for plastic crates in beverage industries
- Refill stations and bottle buy-back programs encouraged under Extended Producer Responsibility (EPR) mandates

While promising, these efforts remain limited to select urban areas and are not yet scalable across Nigeria.

iii. Industrial Circularity

A case study by Abdullahi Tunde (2020) examined the application of CE principles across four industries in Nigeria telecoms, food, pulp & paper, and water packaging. The study found varying levels of material recovery and waste minimization, but also significant barriers such as:

- Lack of technical capacity
- Low awareness among industry leaders
- Insufficient incentives for investment in CE infrastructure (Tunde, 2020)

Enablers and Barriers to Implementation

i. **Enablers**

- Strong informal recycling networks (waste pickers, aggregators)
- Growing awareness of plastic pollution impacts
- Donor-supported initiatives promoting CE models
- Local entrepreneurship and youth-led innovation

ii. Barriers

- Lack of infrastructure for segregation and processing
- Weak policy enforcement and limited incentives for businesses
- Financial constraints and low investment in CE startups
- Inconsistent market demand for recycled materials

Ezeudu et al. (2021) emphasize that enabling a functioning circular economy in Nigeria requires multi-level collaboration between the public sector, private enterprises, and community stakeholders (Ezeudu et al., 2021).

Waste-to-Energy, Buy-Back Programs, and Informal Sector Integration

As Nigeria grapples with rising levels of plastic pollution, especially in urban areas like Diobu, Port Harcourt, alternative waste valorization strategies are gaining attention. These include waste-to-energy (WTE) technologies, plastic buy-back programs, and integration of the informal sector each of which plays a critical role in building an inclusive and circular waste management system.

Waste-to-Energy (WTE)

Waste-to-energy (WTE) involves the conversion of non-recyclable waste materials, including plastics, into usable energy such as electricity, heat, or fuel. Plastics, being petroleum-derived, have high calorific value and offer significant potential as feedstock for WTE in Nigeria.

i. **Potential and Benefits in Nigeria:**
   - Nigeria's municipal solid waste, which includes 9% plastic, contains an estimated 947 million kWh/year of energy potential, equivalent to 2.6% of national electricity demand (Okafor et al., 2022).
   - WTE can reduce landfill volumes, lower methane emissions, and contribute to the national energy mix.
   - Thermo-chemical conversion (e.g., pyrolysis and gasification) has been shown to generate energy while mitigating plastic pollution (Olusunmade et al., 2019).

ii. **Challenges:**
   - Lack of WTE infrastructure and investment
   - High technology costs and energy inefficiency
   - Limited technical capacity and regulatory support

METHODOLOGY

The methodology is a critical component of any academic research as it provides the blueprint that guides how the study will be conducted. For this particular research on sustainable plastic waste management strategies in Diobu, Port Harcourt, the methodology will be carefully designed to **align with the objectives**, **respond to the identified research gaps**, and **remain feasible for an undergraduate study**.

This section outlines the systematic process adopted to gather, analyze, and interpret data with the aim of understanding the sources, impact, stakeholder roles, and effective management strategies for plastic waste within the chosen study area. In line with the **scope** of the study, the methodology will be selected to explore not only the **quantitative aspects** (e.g., the volume of waste, community awareness, usage patterns) but also the **qualitative dimensions**, such as **attitudes, perceptions, institutional practices**, and **barriers to policy implementation**.

Research Design

A research design is the overall framework or plan that guides the collection, measurement, and analysis of data. It is the foundation upon which a study is structured and serves to ensure that the research questions are answered effectively and systematically. For a project evaluating sustainable waste management strategies for reducing plastic pollution in Diobu, Port Harcourt, the research design accommodated both the measurable environmental and behavioral patterns as well as the subjective experiences and institutional dynamics within the community.

As such, this study adopted a mixed-methods research design, which combines quantitative and qualitative approaches. This integration allowed the researcher to benefit from the strengths of both methods while overcoming their individual limitations. The choice of a mixed-methods design was justified based on the need to:

- Quantify patterns of plastic waste generation and disposal (quantitative),
- Explore the motivations, perceptions, and challenges of key stakeholders such as residents, traders, waste collectors, and environmental officials (qualitative),
- Analyze policy effectiveness and the community's response to existing or proposed waste management strategies.

Justification for Mixed-Methods Approach

The decision to use a mixed-methods design stemed from the complexity of the research topic, which could not be fully understood through numerical data alone. Plastic pollution involves environmental, social, institutional, and economic dimensions, and therefore required a multifaceted research approach.

- The quantitative component (e.g., survey questionnaires) enabled the researcher to collect data on household waste generation rates, public awareness, recycling habits, and perceptions of local waste systems.
- The qualitative component (e.g., interviews) provided deeper insights into the lived experiences of individuals involved in waste management, including informal recyclers and local government actors. It also helps uncover the challenges of policy enforcement, cultural practices, and informal systems that influence plastic waste outcomes.

Together, these methods provided a richer, more complete understanding of the problem and contributed to developing realistic, inclusive, and sustainable solutions.

Applicability to Study Objectives

This research design was directly aligned with the main objectives of the study.
The mixed-methods framework ensured that both the scope (broad community patterns) and depth (individual and institutional perspectives) of these objectives were sufficiently addressed.

Practical Considerations

The mixed-methods design also suits the practical limitations and resource availability of an undergraduate researcher:

- Surveys was administered using printed forms within the Diobu community.
- Interviews was conducted with key informants using basic recording tools and note-taking.
- Data was analyzed using simple, accessible software like SPSS for quantitative responses and manual coding for qualitative data.

This ensured that the study remains academically sound, financially feasible, and logistically manageable, without requiring advanced software or laboratory resources.

Study Area

The study was conducted in Diobu, a highly urbanized and densely populated area located in Port Harcourt, the capital city of Rivers State, in southern Nigeria. Diobu is one of the most economically vibrant yet environmentally vulnerable neighborhoods in the state, characterized by a large informal population, unregulated commercial activity, and insufficient public services, especially in the area of waste management.

Geographic and Socioeconomic Context

Diobu is situated in Port Harcourt Local Government Area (PHALGA) and forms a core part of the city's traditional business district. The area is subdivided into several communities, including Mile 1, Mile 2, and Mile 3 Diobu, all of which experience significant human traffic and commercial activity on a daily basis. These features make Diobu a major hub for plastic consumption and disposal, especially of single-use plastics such as:

- Sachet water bags,
- Plastic food containers,

- Polyethylene bags (commonly called "nylon"),
- Plastic bottles and packaging materials.

The neighborhood is home to a diverse mix of residents, including low-income earners, small-scale traders, artisans, students, and informal workers. This demographic profile contributes to high waste generation rates, often without the accompanying infrastructure for organized collection, segregation, or recycling.

Environmental Challenges in Diobu

Diobu faces a range of environmental problems, with plastic pollution being particularly severe. The area suffers from:

i. Blocked drainage channels due to indiscriminate disposal of plastic waste,
ii. Flooding during the rainy season, exacerbated by non-biodegradable waste clogging waterways,
iii. Open dumping and burning of plastics, which contribute to air pollution and health risks,
iv. A lack of adequate waste disposal bins and collection points,
v. Minimal presence of government-regulated recycling infrastructure.

These challenges make Diobu an ideal case study for exploring the real-world consequences of poor plastic waste management in urban Nigeria and for developing sustainable, locally appropriate strategies to address the problem.

Justification for Selection of Study Area

Several reasons informed the selection of Diobu as the focus of this study:

i. High Waste Burden: The area generates a significant volume of plastic waste daily, making it a critical site for investigating urban plastic pollution.
ii. Inadequate Formal Waste Systems: There is a lack of effective government waste services, which provides a unique opportunity to study informal and community-led waste practices.
iii. Vulnerability to Environmental Hazards: The effects of plastic waste are directly visible in the form of flooding, blocked drains, and pollution, which allows for observable impact assessment.
iv. Presence of Informal Waste Actors: Diobu hosts a wide network of informal waste collectors and recyclers whose activities are largely undocumented in academic literature.
v. Policy Relevance: Port Harcourt is governed by the Rivers State Waste Management Agency (RIWAMA), and insights from Diobu can inform broader state-level waste policy reforms.

Target Population

In research, the target population refers to the entire group of individuals, households, organizations, or institutions that possess the characteristics relevant to the research objectives and from which data was collected. For this study, which focused on identifying and assessing sustainable plastic waste management strategies in Diobu, Port Harcourt, the target population consisted of multiple stakeholders who were directly or indirectly involved in the generation, management, and regulation of plastic waste within the study area.

These stakeholders were selected based on their roles in waste production, waste handling, policy implementation, and community-based solutions, making their input crucial to the success of this research.

Composition of the Target Population

The target population was stratified into the following key categories:

i. Household Residents

These are individuals and families living in Diobu who generate plastic waste daily through activities such as:

- Consumption of packaged food and water,

- Shopping in plastic-wrapped goods,
- Domestic use of plastic containers and bags.

They were included to provide data on:

- The volume and types of plastic waste generated at the household level,
- Awareness of environmental issues,
- Willingness to adopt sustainable waste practices like reuse or recycling.

ii. Local Traders and Market Vendors

Marketplaces in Diobu, especially Mile 1, 2, and 3, are hotspots for commercial activities involving extensive use of single-use plastics (e.g., packaging, bags, bottles). This group was included to:

- Understand commercial plastic usage patterns,
- Identify waste disposal methods by traders,
- Gauge the level of environmental responsibility in business practices.

iii. Informal Waste Collectors and Recyclers

This group includes individuals who engaged in:

- Picking plastics from streets, drains, and dump sites,
- Selling collected waste to recycling businesses or middlemen,
- Providing a critical yet underrecognized role in urban plastic waste recovery.

They will offer valuable insight into:

- The informal economy of plastic waste,
- Daily challenges and occupational hazards,
- Opportunities for formal integration into sustainable systems.

iv. Government Agencies and Environmental Officers

Particularly from:

- Rivers State Waste Management Agency (RIWAMA),
- Port Harcourt Local Government Environmental Health Department.

Their role is to:

- Enforce waste laws and sanitation guidelines,
- Provide waste infrastructure and public awareness programs,
- Coordinate formal waste collection and recycling efforts.

Their input will helps assess:

- Policy effectiveness,
- Institutional challenges,
- Recommendations for regulatory improvement.

Environmental NGOs and Community-Based Organizations (CBOs)

These groups were involved in:

- Community sensitization,
- Environmental advocacy,
- Grassroots recycling and clean-up campaigns.

They provide perspectives on:

- Community engagement strategies,
- Education and awareness effectiveness,
- Gaps in support and funding.

Relevance of the Target Population

This population was selected due to its direct connection to the research problem. By engaging a cross-section of stakeholders, the study ensured that it captured the multi-dimensional nature of plastic waste management, including:

- Behavioral,
- Institutional,
- Economic, and

- Policy-related factors.

Engaging a diverse population also enhances the credibility, applicability, and impact of the research findings, ensuring that recommendations are practical and inclusive.

Sampling Technique and Sample Size

Sampling is a critical aspect of research methodology that involves selecting a representative subset of a population for the purpose of data collection and analysis. Due to the impracticality of surveying every individual in Diobu, were carefully selected sample was drawn using appropriate sampling techniques that reflected the characteristics of the broader population. This section outlined both the sampling method used and the justification for the sample size adopted for this study.

Sampling Technique

To ensure that relevant insights was captured from all key stakeholder groups, the study employed a combination of probability and non-probability sampling techniques, specifically:

i. Simple Random Sampling (Probability Sampling)

This was applied to select:

- Household residents and
- Market traders within Diobu for the administration of structured questionnaires.

This technique was chosen because it:

- Ensures fairness and reduces bias,
- Gives every eligible household or trader an equal chance of being selected,
- Helps in collecting generalizable data on waste behavior and awareness levels.

Sampling frames (i.e., residential blocks or market stalls) were identified and numbered, after which respondents will be chosen using a random number generator or interval selection.

ii. Purposive Sampling (Non-Probability Sampling)

This was used to select:

- Informal waste collectors,
- Officials from RIWAMA and local environmental agencies, and
- Leaders of NGOs or community-based environmental groups.

These individuals were deliberately selected based on:

- Their expertise, involvement, or insider perspective on waste management issues,
- Their ability to provide detailed and technical information through interviews or informal conversations,
- Their positional influence on waste policy, enforcement, and community engagement.

This dual sampling approach allows the study to obtain both broad, community-level data and deep institutional and operational insights, thereby improving the quality and balance of the findings.

Data Collection Methods

Data collection is a crucial component of the research process as it provides the empirical foundation upon which findings, conclusions, and recommendations are built. For a study examining plastic waste management in a complex urban setting like Diobu, it is essential to collect data from multiple sources and perspectives to ensure a comprehensive understanding of the issue. This study employed a multi-instrument data collection approach to accommodate the diversity of the target population and the mixed-methods.

The two main data collection methods used were:

- Structured questionnaires for the quantitative component, and
- Semi-structured interviews for the qualitative component.

Structured Questionnaire (Quantitative Tool)
A structured questionnaire was developed and administered to residents and market traders to gather quantitative data on their plastic usage patterns, waste disposal habits, and awareness of plastic pollution.

Structure and Content
The questionnaire was divided into four major sections:

i. Demographic Information – Age, gender, occupation, education level.
ii. Plastic Use and Disposal Behavior – Frequency and types of plastic used, waste disposal methods, recycling practices.
iii. Environmental Awareness – Knowledge of the environmental impact of plastic waste.
iv. Attitudes Toward Sustainable Practices – Willingness to reduce usage, support for recycling programs, and views on government interventions.

The questions consist mainly of closed-ended formats, including:

- Multiple-choice questions,
- Yes/No options,
- Likert scale ratings (e.g., Strongly Agree to Strongly Disagree).

Administration

- The questionnaire was administered in person to increase the response rate and allow for clarification where necessary.
- Assistance was provided to participants with low literacy levels.
- Responses were recorded immediately on printed forms.

Key Informant Interviews (Qualitative Tool)
To complement the survey findings and gain in-depth insights, semi-structured interviews was conducted with selected key informants. This method was used because it allows for:

- Flexibility in questioning, enabling follow-up on emerging issues,
- Narrative responses, offering detailed personal and professional insights,
- Contextual exploration of institutional and informal waste management practices.

Data analysis Techniques
Data analysis is the process of organizing, interpreting, and drawing conclusions from the information collected during the research. The goal of this section is to explain how both quantitative and qualitative data gathered from the field were processed to answer the study's research questions and meet its objectives. Since this study adopted a mixed-methods approach, both statistical and thematic techniques were employed.

Quantitative Data Analysis
Quantitative data was derived primarily from structured questionnaires administered to household residents and market traders. These data were analyzed using the Statistical Package for the Social Sciences (SPSS) a widely used and student-friendly software that enables accurate data handling and interpretation.

Coding and Entry

- All questionnaire responses were coded numerically and entered into SPSS Version 25.
- For example, "Yes" = 1, "No" = 0, and Likert-scale responses was assigned values from 1 (Strongly Disagree) to 5 (Strongly Agree).
- Data cleaning was performed to eliminate incomplete or inconsistent entries.

Descriptive Statistics
Descriptive statistics was used to summarize and describe the basic features of the dataset. This included:

- Frequencies and percentages – to show the distribution of responses (e.g., percentage of respondents who use plastic bags daily),
- Cross-tabulations – to examine relationships between variables (e.g., educational level and awareness of plastic pollution).

These statistical tools help to identify patterns in plastic waste behavior and public perceptions within the Diobu community.

Qualitative Data Analysis
Qualitative data was collected from semi-structured interviews with key informants, including RIWAMA officials, informal waste collectors, and local environmental advocates. These responses require a different analysis approach, focused on extracting meaning and insight from words rather than numbers.

Transcription

- All interviews will be transcribed either manually or using audio playback.
- Key quotes will be extracted and labeled according to themes or topics.

Thematic Analysis
Thematic analysis was used to organize and interpret qualitative responses. This involved:

- Reading and re-reading transcripts to become familiar with the data,
- Coding responses under recurring themes such as:
  - "Challenges in waste enforcement,"
  - "Informal sector contributions,"
  - "Barriers to public participation,"
  - "Suggested policy improvements."
- Grouping similar codes into broader categories and interpreting the meaning in relation to the study objectives.

This method helps to uncover hidden insights, contextualize survey findings, and amplify the voices of stakeholders often underrepresented in policy discussions.

Integration of Quantitative and Qualitative Data
Given the mixed-methods nature of the research, both data types were integrated during interpretation to enrich the findings. This triangulation approach allow the researcher to:

- Validate trends observed in the surveys with explanations provided in interviews,
- Contrast public opinions with institutional perspectives,
- Develop a holistic understanding of plastic waste issues in Diobu.

For example, if survey data revealed low levels of recycling behavior, interview data from informal collectors might explain this due to lack of infrastructure or policy support.

Ethical Considerations
Ethical considerations are a fundamental aspect of research, particularly when human participants are involved. Upholding ethical standards ensures that the rights, dignity, and welfare of participants are protected throughout the research process. For this study, which involved gathering data from residents, traders, informal waste collectors, and government officials in Diobu, strict ethical guidelines will be observed at every stage of data collection and reporting.
The ethical principles followed will be based on four key pillars: informed consent, confidentiality, voluntary participation, and academic integrity.

Informed Consent

Before any data was collected, all participants were provided with a clear explanation of:

- The purpose of the study,
- The type of information they would be asked to provide,
- The use of their responses, and
- Their rights as participants.

Respondents were given a simple informed consent form (written or verbal, depending on literacy level), which they required to agree to before participation. The form explained that:

- Participation was entirely voluntary,
- There were no penalties for choosing not to participate,
- They could withdraw from the study at any time, even after beginning.

Participants were also informed that their responses would be used solely for academic purposes and would not be shared with third parties.

Confidentiality and Anonymity

To protect participant privacy:

- No personally identifiable information (e.g., full names, addresses, phone numbers) was recorded or reported.
- All responses were treated as anonymous and stored securely.
- In cases where direct quotes from interviews were used in the report, they were attributed to generic identifiers such as "Trader A" or "RIWAMA Official 1."

Only the researcher and supervising academic staff had access to the raw data. This approach helped create a trustworthy environment, encouraging honest and open responses from participants, especially on sensitive topics like policy criticism or informal waste activities.

Voluntary Participation

Participation in the study was completely voluntary. Respondents were not coerced, misled, or incentivized to participate. During the data collection process:

- Participants were clearly informed that refusal to participate would have no consequences,
- They were allowed to skip any question they were not comfortable answering,
- They could exit the interview or questionnaire process at any point without justification.

This ensured that all responses were given freely and ethically, maintaining the integrity of the data.

Respect and Cultural Sensitivity

Given the diverse cultural and socioeconomic background of Diobu residents:

- Questions was designed to be simple, respectful, and free of judgment,
- Language was adapted for local understanding (e.g., using common local terms for plastic waste items),
- Field assistants (if used) were trained to communicate clearly and respectfully with all respondent groups.

Extra care was taken when engaging informal waste workers and traders, many of whom may have had limited formal education, to avoid language barriers or perceived intimidation

Table 3.1: Geographic Positioning System Coordinates for the Study Locations

S/No	Latitude	Longitude
1	4.788781^{o}	7.000870^{o}
2	4.791294^{o}	6.998238^{o}
3	4.792492^{o}	6.997283^{o}
4	4.797852^{o}	6.992375^{o}
5	4.793681^{o}	6.994986^{o}
6	4.793478^{o}	6.995989^{o}

7	4.800881°	6.990710°
8	4.802181°	6.990069°
9	4.803526°	6.989751°
10	4.803961°	6.989674°

RESULT PRESENTATION AND DISCUSSION

Result Presentation

Table 4.1: Questionnaire Distribution and Retrieval

S/NO	Questionnaire	Frequency	Percent (%)
	Administered	300	100
	Unretrieved	26	8.7
	Retrieved	274	91.3
	Total	300	100

Table 4.1 presents the questionnaire distribution and retrieval. Here is the information on the questionnaire that was administered to the respondents in the study area to assess their perceptions on health risk of high noise in the study area. From the table, 300 (100%) copies of the questionnaires were administered, 26 (8.7%) copies were not retrieved and the remaining 274 (91.3%) were retrieved and used for the computation.

Table 4.2: Demographic Characteristics of Respondents

Variables	Frequency	Percentage (%)
Sex		
Male	163	59.5
Female	111	40.5
Total	**274**	**100**
Age		
Less than 35years	56	20.4
36-50years	129	47.1
51years and above	89	32.5
Total	**274**	**100**
Married Status		
Single	66	24.2
Married	160	58.4
Widowed/Widowered	45	16.4
Divorced	23	8.4
Total	**274**	**100**
Education Qualification		
Primary	19	6.9
Secondary	152	55.5
Tertiary	103	37.6
Total	**274**	**100**
Occupation		
Farming	16	6.9
Civil Servant	34	12.4
Trading	163	59.5
Artisan	56	20.4
Others	5	1.6
Total	**274**	**100**

Source: Researcher's Fieldwork, 2025.

Table 4.2 presents the demographic characteristics of the respondents in the study area. From the response, 59.5% are male while 40.5% are females. It shows the majority of the respondents were males.
The age bracket of the respondents are as follows; 20.4% were less than 35 years, 47.1% were 36-50 years, 32.5% were 51 years and above. It shows the highest respondent were within the age bracket of 36-50years.
Thus, from the married status of the respondents, we have 24.2% are single, 58.4% are married, 16.4% are widowed/widowered while 8.4% are divorced. This reveals that the married respondents were more.
The educational qualification of the respondent was affirmed 6.9% attained primary school, 55.5% attained secondary education while 37.6% has tertiary education. From this, those with secondary education were of majority of the respondents.
However, on the occupation of the respondent, 6.9% of them are farmers, 12,4% are civil servants, 59.5% are involved in trading, 20.4% are artisans while 1.6% of them are affirmed as others. Thus, the respondents were more of civil servants.

Table 4.3: Do you use or consume food or water contained in plastics?

Response	Frequency	Percent (%)
Yes	274	100
No	0	0
Total	274	100

Source: Researcher's Fieldwork, 2025.
Table 4.3 presents the responses of the respondents on their use of plastic contents. From the response, all the respondents (100%) make use of plastics.

Tables 4.4: Do you dispose-of the plastics after used up the content?

Response	Frequency	Percent (%)
Yes	152	55.5
No	122	44.5
Total	274	100

Source: Researcher's Fieldwork, 2025.
Table 4.4 presents the response of respondents on what they do with the used-up plastics. Thus, 55.5% of them says they dispose them off while 44.5% says they do not.

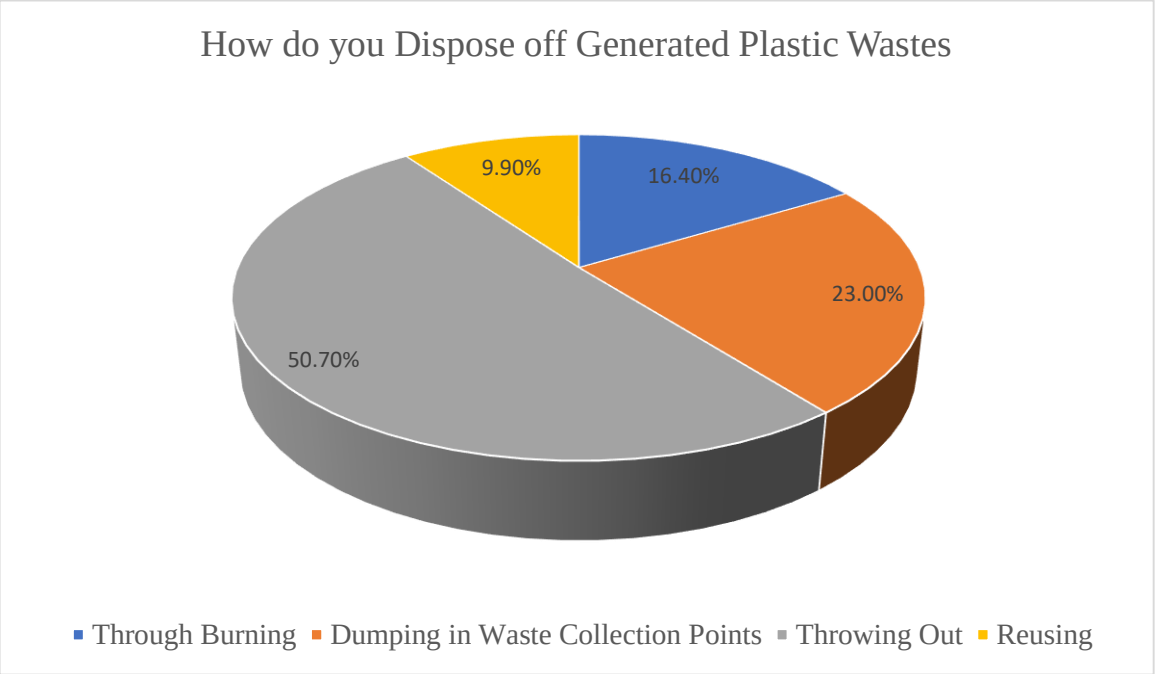

Figure 4,1: How do you Dispose-off Generated Plastic Wastes

Figure 4.1 presents the respondents' ways of disposing off their waste. 16.4% says through burning, 23.0% says they dump in waste collection points, 50.7% says they just throw them out while 9.9% says they reuse them.

Table 4.5: Current State of Plastic Pollution in the Area

Response	Frequency	Percent (%)
Bad	74	27.0
Not that bad	19	6.9
Good	65	23.7
Not that good	116	42.3
Total	274	100

Source: Researcher's Fieldwork, 2025.

Table 4.5 presents the responses of the respondents on the current state of plastic waste pollution in the area. 27.0% says it is bad, 6.9% says not that bad, 23.7% it is good while 42.3% says it is not that good.

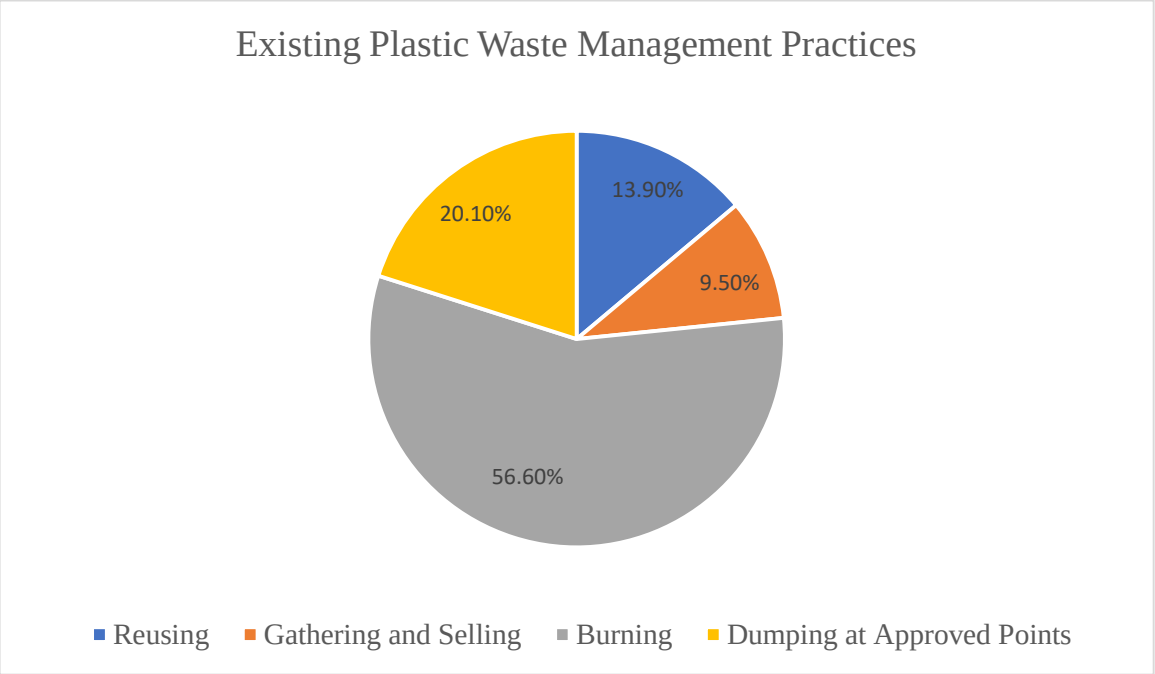

Figure 4.2: Existing Plastic Waste Management Practice

Figure 4.2 presents the responses on existing plastic waste management practice in the area. 13.9% affirmed reusing, 9.5% says gathering and selling, 56.6% says burning, 20.1% says dumping at approved points.

Table 4.6: Improper Plastic Waste Management can lead to blockage of Water Channels and Cause Flooding

Response	Frequency	Percent (%)
Agree	52	19.0
Strongly agree	61	22.3
Disagree	42	15.3
Strongly disagree	34	12.4
Undecided	85	31.0
Total	274	100

Source: Researcher's Fieldwork, 2025.

Table 4.6 presents the response on the impact of improper waste management leading to blockage of water channels and consequently flooding. 41.3% agree to it, 27.7% disagree while 31.0% were undecided.

Table 4.7: Poorly Managed Plastic Wastes can leach Chemicals into Surface and Groundwater and contaminate drinking sources and causing Gastrointestinal diseases, Kidney and Liver damage

Response	Frequency	Percent (%)
Agree	47	17.2
Strongly agree	38	13.9
Disagree	36	13.1
Strongly disagree	22	8.0
Unaware	111	40.5
Total	274	100

Source: Researcher's Fiedwork, 2025.

Table 4.9 presents the responses on the impact of improper plastic waste management. 31.1% agreed to the statement, 21.1% disagreed while 40.5% were unaware.

Table 4.8: Improper Plastic Waste Disposal can be a breeding ground for vectors

Response	Frequency	Percent (%)
Agree	40	14.6
Strongly agree	52	19.0
Disagree	45	16.4
Strongly disagree	38	13.9
Unaware	99	36.1
Total	274	100

Source: Researcher's Fieldwork, 2025.

Table 4.8 presents the response on improper plastic waste disposal leading to breeding ground for disease vectors. 33.6% agreed to the impact, 13.9% disagreed while 36.1% were unaware.

Table 4.10: Are you aware plastic waste if not properly managed can be dangerous to the Environment

Response	Frequency	Percent (%)
Yes	109	39.8
No	84	30.7
Unaware	81	29.6
Total	274	100

Source: Researcher's Fieldwork, 2025.

Table 4.10 presents the response on the respondents' awareness of danger of improper plastic waste management to the environment. Thus, 39.8% affirmed Yes, 30.7% say No while 29.6% said they are not aware.

Table 4.11: Do you think recycling Plastics instead of littering them is a good practice?

Response	Frequency	Percent (%)
Yes	86	31.4
No	37	13.5
Undecided	151	55.1
Total	274	100

Source: Researcher's Fieldwork, 2025.

Table 4.11 presents the response on recycling of plastics. 31.4 affirmed its is good to recycle plastics, 13.5% said it is not while 55.1% were undecided.

Table 4.12: Do you imbibe the culture of Environmental responsibility by always making sure Plastics are not littered in your place of residence?

Response	Frequency	Percent (%)
Yes	41	15.0
No	166	60.6
Sometime	67	24.5
Total	274	100

Source: Researcher's Fieldwork, 2025.

Table 4.12 presents the response on environmental responsibility of the respondents in managing plastic wastes in their areas. 15.0% affirmed they practice it, 60.6% said they do not while 24.5% said they sometimes do.

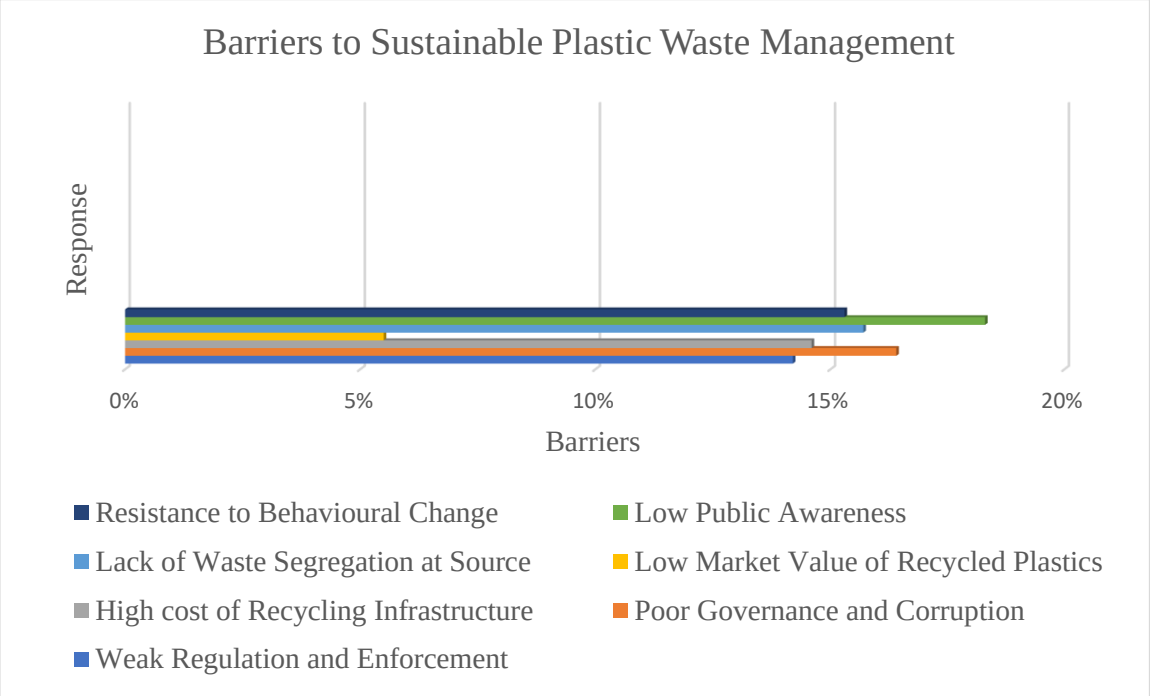

Figure 4.3: Barriers to Sustainable Plastic Waste Management

Figure 4.3 shows the barriers to sustainable plastic waste management. From the responses, these barriers are resistance to behavioural change, high cost of recycling infrastructure, weak regulations and enforcement, low public awareness, low market value of recycled plastics and poor governance and corruption.

Figure 4.4: Practical and Community-Based Strategies for Managing Plastic Wastes

Figure 4.4 displays the practical and community-based strategies for recycling plastic wastes. From the responses, these strategies are waste segregation at source, promoting reuse and alternatives, plastics collection and recycling hubs, awareness campaign, community clean-up, partnership with informal waste pickers and plastics-for-value initiatives.

Discussion

From the field assessment and the general responses of the various respondents, one can deduce that the residents of Diobu are confronted with the challenges of plastic pollution. As observed, the respondents acknowledge the current state of plastic pollution in the areas which they affirmed that it is in a bad state. Thus, when asked the existing plastic waste management practices in the area, 16.4% says through burning, 23.0% says they dump in waste collection points, 50.7% says they just throw them out while 9.9% says they reuse them. From the response it is observed majority agreed they just throw them out after usage which will have a deleterious effect on the environment. However, the environmental health impact of improper plastic waste disposal is worrisome. It ranges from blockage of water channels and cause flooding, leaching of chemicals into surface and groundwater and contaminating drinking sources and causing gastrointestinal diseases, kidney and liver damage, can be a breeding ground for disease vectors. When the respondents were assessed of their awareness on plastic waste recycling and environmental responsibility, it appears they have limited knowledge of what that means. The barriers to achieving sustainable plastic waste reduction in the study area have been identified as resistance to behavioural change, high cost of recycling infrastructure, weak regulations and enforcement, low public awareness, low market value of recycled plastics and poor governance and corruption. These factors were not just itemized by the researcher but were equally upheld by the respondents and some key environmental stakeholders. This is true as majority of the set back to achieving sustainability in plastic waste management are centred around these barriers. Owing to these, the research proposes practical and community-based strategies for reducing plastic waste pollution in the study area; these strategies are waste segregation at source, promoting reuse and alternatives, plastics collection and recycling hubs, awareness campaign, community clean-up, partnership with informal waste pickers and plastics-for-value initiatives.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Plastic pollution has emerged as one of the most pressing environmental challenges of the 21st century, posing serious risk to ecosystems, human health and urban sustainability. Sustainable waste management strategies provide a holistic approach to tackling these challenges by emphasizing prevention, efficient resource use and environmental stewardship. Thus, key strategies such segregation at source, promoting reuse and alternatives, plastics-for-value initiatives, partnership with informal waste pickers, community-based clean-up among others can drastically reduce plastic waste leakages into the environment. These approaches will not only minimize the harmful impacts of plastics but also create jobs, cleaner urban environments and circular economies where materials will be continuously reused. By adopting sustainable waste management practices, the study area and government can move closer to achieving long-term ecological balance and safeguarding public health while reducing the burden of plastic pollution.

Recommendation

i Improve source separation and door-to-door Collection: this requires or encourages households and businesses to separate recyclable (plastics, metals, paper, organics) into two or three streams at source. This will reduce contamination and as well lowers landfill loads.

ii Formalize and Support the Informal Recycling Sector (waste pickers): integrate waste pickers into collection and sorting networks. Informal workers already recover large shares of recyclable plastics; formalization increases workers' and recycling efficiency.

iii Create Neighborhood Material Recovery/Sorting Hubs and Buy-Back Centers: here, plastics are sorted, cleaned, compacted and sold to recyclers. Local MRFs reduce transport cost, create jobs and increase quality of recyclables so local recyclers can buy them.

iv Implement Extended Producer Responsibility and Deposit-Return Schemes: this requires beverage and sachet producers to finance collection/recycling (producers take-back) and introduce refundable deposit on PET bottles. This shift cost to producers and creates financial incentives to return packing.

v Tackle Sachet Water Waste Specifically: promote refill stations, larger multi-use dispensers, and refundable sachet-collection program.

vi Ban or Restrict the Worst Single-Use Items and Offer Affordable Alternatives: plastics restrictions on foams, single-use cutlery and non-recyclable packaging while promoting affordable re-usable options for vendors.

vii Public Education, School Programs and Community Campaigns: behavioural change campaign-focus on littering, river dump, reuse and segregation.

viii Support Local Recycling Businesses and Create Markets for recycled Plastics

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