

Environmental Effectiveness and Community Participation in Sustainable Solid Waste Management Practices in Freetown City, Sierra Leone

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Abstract: In many developing African cities, municipalities' incapability to handle the growing amount of waste produced is becoming a worrisome concern. When solid waste management practices are outlined in terms of their sources, generation rate, transport capacity, transfer, and physical composition, they may be effective. The lack of timely information about waste generation, composition, environmental effectiveness, and community involvement in the solid waste management system in Freetown has been identified as a serious impediment to the long-term management of municipal solid waste practices. An evaluation of the difficulties of municipal solid waste management in the Freetown Western Area was conducted in this study by looking at environmental effectiveness and community participation. The Freetown Solid Waste Management (FSWM) was evaluated using a conceptual model of environmental effectiveness proposed by Kütting to see how ecologically efficient it is at ameliorating the horrible environmental impacts of solid waste. The study discovered that the current solid waste management system does not enhance environmental effectiveness and has a negative impact on the community. Inability to sufficiently separate waste at the source, and reduces the amount for final disposal implies a lack of community participation, environmental effectiveness, and institutional control of municipal solid waste handling. This analysis revealed that Freetown practices the least favoured option in the waste management hierarchy. That is, the first and best practice is to dispose of waste in waste dumps. The authors strongly recommend that the approach to these determinants focus on how solid waste is treated, rather than how waste is simply removed for final disposal.

Keywords: Environmental Effectiveness, Municipal Solid Waste, Determinants, Community Participation, Freetown

1. Introduction

Management of municipal solid waste is fast becoming a critical environmental problem, not only for cities in developing countries but equally so for those in developed nations. While the amount of solid waste produced in cities on daily basis continues to increase, the effectiveness of managing it with respect to storage, collection, transportation and disposal leaves much to be desired. We are now challenged by the massive volume of solid waste that people produce every day globally. "Around the world, waste generation rates are rising. In 2016, the worlds' cities generated 2.01 billion tonnes of solid waste, amounting to a footprint of 0.74 kilograms per person per day [1]. With rapid

population growth and urbanization, annual waste generation is expected to increase by 70% from 2016 levels to 3.40 billion tonnes in 2050" [1, 2].

Residents of developing countries, particularly the urban poor, are more severely affected by unsustainable garbage management than those in developed countries. Over 90% of rubbish in low-income countries is usually disposed of in unregulated dumps or burned openly. These activities have major effects on people's health, safety, and the environment. Waste that is not properly handled acts as a breeding ground for disease vectors, contributes to global climate change by generating methane, and can even fuel

urban violence. [3, 4]

Waste Management is critical for developing cities that are going to be sustainable and livable, but for many of these underdeveloped countries and towns, this is still a huge problem. Freetown City is not exempted from such a challenge. Some pieces of literature such as [5–7] have stated that effective waste management is costly and often accounting for 20% to 50% of municipal budgets. Operating municipal solid waste management services requires integrated systems that are efficient, sustainable, and socially supported.

“The world generates 2.01 billion tonnes of municipal solid waste annually, with at least 33% of that extremely conservatively. That is, not managed in an environmentally safe manner [1, 8]. Worldwide, waste generated per person per day averages 0.74 kilograms, but ranges widely, from 0.11 to 4.54 kilograms. Though they only account for 16% of the world’s population, high-income countries generate about 34 percent or 683 million tonnes of the world’s waste” [1].

Storage, transportation, prevention, characterization, monitoring, treatment, handling, reuse, and residual disposal of solid wastes are all part of the management of municipal solid waste. Several forms of solid waste do exist. These include municipal (residential, institutional, commercial), agricultural, and special (health care, hazardous wastes, sewage sludge etc.). According to Ogwueleka [9], municipal solid wastes from industrial, commercial, and institutional institutions (including hospitals), market wastes, yard wastes, and street sweepings are all part of the management of municipal solid waste.

Solid waste management is one of the serious fears facing developing nations because of the socio-economic and environmental implications if not suitably handled. Studies reveal that only 35-50% of the waste produced in developing nations is collected and managed correctly [10]. The rest is either burned or left to decompose in open space or dumped in unregulated landfills, which is detrimental to the environment. In Freetown, like other developing nations, the increase of solid waste generation is principally due to rapid urbanization and population booming following the end of the 11 years brutal civil war.

Poor solid waste management is a result of numerous intertwined factors. Some of these factors are environmental effectiveness, non-participation by communities, governance poor drive, and institutional incapacity to efficiently handle the generated waste. The principal sources of municipal solid wastes in Freetown are commercial activities, residences, street sweeping, institutions, and mini-industries. A significant amount of solid waste in Freetown is generated from residential areas and local marketplaces.

Waste management problems are getting complex in Freetown as a result of urbanization, population growth, expansion of informal settlement and business, lack of proper governance regulatory policy, lack of awareness by inhabitants on a poor waste management practice, inept

knowledge on the subject of “the duty of care”, carelessness, incapacitated approach of municipal authorities. This is compounded by poor community participation. As such, it keeps exacerbating the problems of municipal solid waste management.

Solid waste can be a valuable resource if it is properly managed. If it is not well managed, however, it can have a negative influence on the environment and public health. [11, 12]. The provision of adequate solid waste management facilities in an urban area is a vital investment that protects the health and wellbeing of the individuals living in towns and cities, as well as protects the environment. This research is therefore aimed at evaluating SWM practice in Freetown through a critical look at the role of environmental effectiveness, community participation and governance and examine the knowledge base of the community about MSWM.

1.1. Research Questions

To achieve the aim of the research, the following research questions are formulated undermentioned:

- 1) How might environmental effectiveness, governance, and community participation in Freetown help to create a long-term waste management strategy?
- 2) Are the current waste management practice(s) sufficient enough to prevent waste-related negative impacts in Freetown?
- 3) Which waste management hierarchy approaches do the stakeholders in the study area implement to ensure environmental effectiveness, community participation, and governance?

1.2. Significance of the Research

Credible information about the overarching influence of governance, community participation and environmental effectiveness on municipal solid waste management is important to design a suitable solid waste management strategy that can minimize the adverse environmental impacts of solid waste in the study area. This study is anticipated to be useful in the following ways:

- 1) It will give some guideline information to alleviate problems related to the management practices of solid waste in the study area,
- 2) Second, the study will underwrite a better theoretical understanding of the inclusive features of municipal solid waste and problems faced in the process of municipal solid waste management in the Freetown Central Zone population,
- 3) Third, it is expected that this study gives some recommendation(s) to Freetown City Council, policymakers, public administrators, solid waste service providers, researchers and environmental protection agencies who desire to improve existing solid waste management practices and to curtail related problems,
- 4) The study may also be significant in putting

reference point information to the next work as a foundation for academics who would like to carry out thorough and all-inclusive studies either in the Central Zone or other municipalities in the country and elsewhere.

1.3. Statement of the Problem

Freetown Municipality has been characterized by an increase in population growth since the end of the 11 years civil war. This has led to rapidly increasing volumes of solid waste which is illegitimately dumped on open sites. Freetown Western Urban District has been exclusively selected as the study area, because it is the most mixed

populous trading hub of the country, and experiences a huge pressure of floating population [13–15]. Owing to this rapid pressure in the population, all sorts of waste and related residual materials have been enormously increased in the study area.

Majority of the people residing in Freetown generate and dispose of different types of waste in an indiscriminate manner due to a lack of approved communal disposal sites and /or inadequate skip containers. This is manifested and palpable insight of trash deposits almost everywhere; litters dumped alongside streets, clogging streams, buildings etc. figure 1.

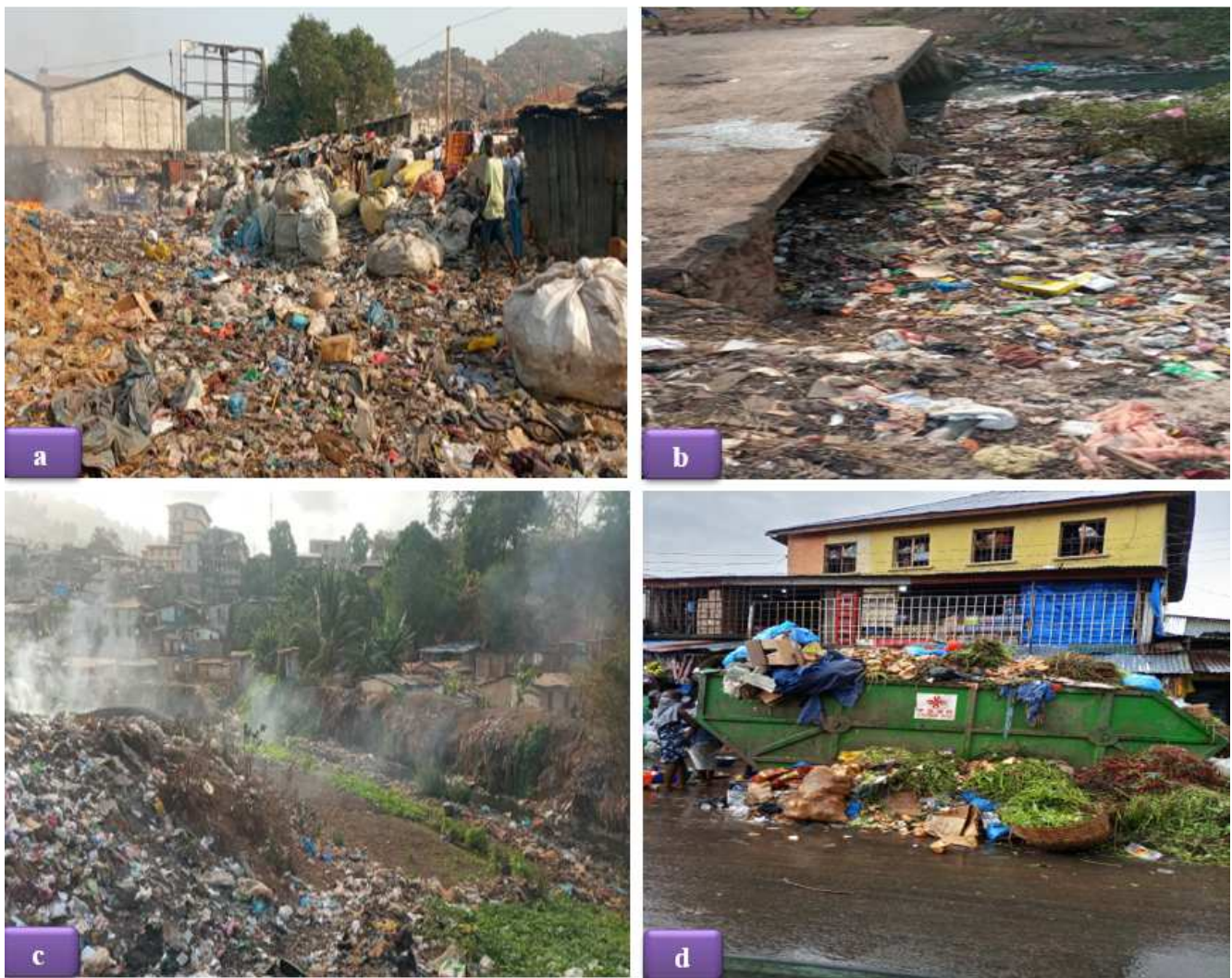


Figure 1. Poor environmental waste management in Freetown; a & c (Granville Brook dumpsite-open burning of waste, creating air pollution. b (culvert clogged with waste) and d (waste spillage from skip container along a major street in the west-end of Freetown City).

Several emerging Solid Waste Management (SWM) techniques that have been attempted to encourage a long-term solid waste management strategy proved to be insufficient and seemingly futile. A few studies by Sankoh et al., [14], World Bank [16], Sierra Leone Population and Housing Census [17] have been carried out about Solid Waste Management Plan (SWMP) in Sierra Leone, but

factors such as environmental effectiveness, governance and the role of community participation have not been well explored, thoroughly integrated and/or truly understood to solve problems associated with solid waste management within the study area and other municipalities across the country at large. These are major influencing factors for sustainable and effective SWM

practices. Thus, there is an urgent need to assess these factors and their resonating environmental implications in Freetown, so that corrective measures can be promulgated. The focus of this study was to investigate the impact of community participation in promoting sustainable municipal solid waste management practices in Freetown, Sierra Leone's capital city using the environmental effectiveness paradigm.

1.4. Conceptual Framework

In this research, Kutting [18–20] conceptual framework of environmental effectiveness is used to assess how ecologically effective Freetown Central SWM is in reducing the negative effects of solid waste on the environment. The conservative analysis of effectiveness, which focuses mostly on institutional performance and less on governance and the role of community engagement, may be overcome by this sense of environmental effectiveness. Even with a strong and satisfactory institutional effectiveness, sustainable solid waste management practices will fall of their goals if environmental necessities are trivialised.

Some studies on solid waste management are concerned with the “why”, “who”, “how” and “what” of the management paradigm [21, 22]. A number of studies that have been done are more concerned with the function of waste management than with its effectiveness in preventing the negative consequences of solid waste on the environment at every level.

1.5. Limitation of the Framework

This framework is not devoid of limitations. As a result, I feel compelled to point out the study's drawbacks at this stage. The most significant limitation is putting into practice a concept that is used in international relations. Even though this study derives its framework-“environmental effectiveness” from the study done by Kütting, her account may not completely appropriate the existing conditions of waste management at a municipal level, as in the case of Freetown Central. According to Kütting [18, 19], she makes known the environmental effectiveness and its four elements, otherwise described as “determinants” in her international relations research work. This is intended specifically for international environmental treaties.

International environmental agreements and waste management differ enormously. The fundamental distinction is in their organizational structures. Treaties on international environmental issues are defined as formal or informal agreements between states that seek to recognize, regulate or, rather, collectively eradicate an environmental problem. [19]. Treaties differ from national laws in that there is no power to compel individual states to comply with international environmental agreements or protocols. Furthermore, there is no global police force that will compel governments to carry out these responsibilities and /or guidelines in the treaties. As a result of the lack of sovereignty and police force in the agreements,

international environmental agreements place the permission of the participating governments at the centre.

National or regional governments, on the other hand, regulate waste management through rules and regulations, whereas an international agreement does not rely simply on all parties' participation. Even though member agreement is just as vital in national governments as it is in international environmental agreements, police forces are on the scene to force members to adhere to waste management standards. It is quite challenging to measure and quantify environmental effectiveness, in terms of numbers or statistics. There are no known mathematical tools or equations to show how the four elements shape environmental effectiveness.

Furthermore, due to a lack of extensive evaluation of the four determinants, analysis with them can be prescriptive. For example, the issue of which of the four factors is the best indication of environmental performance has no obvious solution. Additionally, the governance networks study raises an alarming aspect, stating that governance network research appears to be problem-driven rather than theory-driven. [23, 24]. A concern expressed by Torfing is that governance networks studies might be the deficiency of a theoretical ground and the painstaking use of research methods. Until now, Torfing has recommended that well-designed research questions and methodologies, such as qualitative interviews and policy-related document appraisals can help handle this concern. The aforementioned are the framework's main drawbacks.

1.6. Environmental Effectiveness

Many studies focus on the function of waste management rather than its effectiveness in reducing waste's detrimental impact on the environment. As a result, this current research is unable to adequately answer questions such as:

- 1) Is waste recycling the most environmentally friendly way to dispose of waste?
- 2) Is energy recovery from solid waste a circular economy resource management approach?
- 3) Why is it so challenging to promote waste prevention and reuse strategies, although they are the most desirable approaches in the waste management hierarchy?

However, some ground-breaking studies look at the current waste management system's inadequacies from a global perspective scheme. These studies [25–27] allude that, management of solid waste must decide to steer modern-day performance in the direction of more ecologically friendly options, such as reuse and waste prevention. For instance, Bell and Sweeting [27] contend that the present waste policy in Bristol, UK, places more economic burdens on households, while it is in favour of business actors. They claim that the root of this skewed approach is a policy framework that prioritizes recycling over trash reduction [28].

It's difficult to locate research that evaluates waste management's effectiveness in addressing waste-related

environmental issues, as well as how far waste management is on the cutting-edge in terms of gaining more control over waste and environmental issues. As a result, the idea of "environmental effectiveness" can be used to assess the efficacy of waste management in the context of its four key determinants: economic structures, time, science, and regulatory structures. Additionally, environmental effectiveness pictures out how waste management utilizes the four determinants in the management course, to create a more environmentally effective method in waste management.

1.7. Determinants of Environmental Effectiveness

It is feasible to find out how these four criteria relate to waste management, environmental issues, and societal structures.

1.7.1. Regulatory Structure

Institutional effectiveness is determined by the regulatory structure. For the following reasons, it focuses on administrative feasibility rather than environmental needs: first, policymakers in a regulatory structure are government officials who do not represent the environment, but rather the government; second, policymakers work within a rigid and irregular administrative structure, so they cannot easily embrace the entire picture of environmental degradation.

Waste governance can be analyzed using these characteristics of the regulatory structure to environmental effectiveness in waste management in the study area, using the following questions: What does solid waste management entail? Who are the people who are participating in it? What are their tasks and roles? What kinds of impediments may arise in the waste collection process? How do these impediments hinder the environmental effects of waste management?

1.7.2. Time

Time is a significant determinant of environmental effectiveness owing to its two exclusive features. The first being; its "irreversibility", and the second; its "rhythmicity". The irreversibility talks about the impossibility to recover the environment once it has already been seriously devastated. Rhythmicity of time is a pretty new concept, and it can be out into two categories: linear and circular.

According to Kutting [20], the essential belief of contemporary society which she sees as a mechanistic system is linear rhythmicity. Kutting defines mechanistic systems as "human-made, and the throw-away society, which replaces discrete pieces but does not reuse them, is the best example". Because the mechanistic system has recognized the concept of "splitting an object into parts that can be analyzed independently and easily replaced," these throw-away behaviours are authorized. Circular rhythmicity, on the other hand, denotes the environmental principle that is represented in an organic system.

Organic systems are focused on resource recycling and

renewal. As a result, a constant energy cycle is produced, which is more in line with the circular economy concept. The mismatch between a mechanical system ("man-made contemporary society") and an organic system ("the environment") causes environmental degradation. The mechanical system that characterizes linear rhythmicity is dependent on wasting and consuming a large amount of resources, resulting in negative environmental consequences.

The characteristics of time, as elucidated by Kutting, offer first and foremost fascinating views in light of time's irreversible for assessing waste management in Freetown Central Zone. In the First place, FCC must make an effort to avoid exacerbating environmental degradation within a certain time frame, recognizing the irreversibility of environmental concerns. As a result, it is critical to comprehend how those in charge of waste management view this irreversibility and what they will do to avert similar environmental degradation as a result of hazardous waste. It is also important to recognize the variables that prevent the implementation of new rules and programs aimed at promoting more advanced waste management approaches. Moreover, it is critical to figure out how powerful waste management practice relates to the circular rhythmicity of time in waste strategy.

Approaches to waste treatment in the waste management hierarchy can be characterized by representing either linear or circular features. Landfilling and incinerating without energy recovery are examples of waste disposal processes that show linear rhythmicity. This is because the value of waste will be lost in landfills or incinerators. Recycling and reuse methods, in contrast to these two approaches, can be regarded as exhibiting circular rhythmicity, as trash is reused by partially or replacing virgin resources.

Energy recovery which sits at the middle of the hierarchy between disposal and recycling methods reflects the circular belief to a large degree. Since this technique uses waste as a resource to generate energy for electricity. Waste management actors (FCC, ministry of environment) and ministry of energy resources should collaborate to promote energy recovery from waste.

1.7.3. Economic Structure

Economic structures are key determinants of environmental effectiveness, as economic structures normally determine social organization. These structures also decide how the environment and environmental issues are perceived in society. Kutting [20] argues that green technology is perceived as a looked-for method to overcome environmental degradation and sustain economic growth at the same time. This is because the current society has such a sturdy belief in the possibility of unlimited progress and economic growth.

Kutting's analysis is demonstrated in the relationship between waste management and economic structures. In the first place, the present economic structure in Freetown is typified by mass production and consumption, which is

inevitably connected to the massive amount of waste generation. It is a common practice in the Freetown Central One Zone to buy products and throw them away, as it is easy and cheap.

Furthermore, given the economic factors at the institutional level, it is obvious that the economic factors limit the current waste management system from investing and developing better waste management strategies in Freetown. For instance, due to the high cost of introducing a new solid waste treatment system, big waste management actors and companies like “Masada”, “Kiln Salone”, “Yeane” might hesitate to implement it, even if the system is more environmentally friendly. To crown it, the economic concern is occasionally prioritized over environmental needs. Thus, understanding the economic structure is ultimate in identifying the problems concerning waste generation, and in looking for solutions by understanding the financial walls to execute and enhance the existing waste management.

1.7.4. Science

Science is a crucial determinant of environmental effectiveness because policymakers rely upon scientific know-how to recognize environmental issues and to discover viable answers for them. The other significant point of science is that science is a social activity that cannot be isolated from other social activities. Science gives information and allows the prediction of negative impacts originating from waste in the environment. Thus, this enlightens policymakers and residents about the terrible consequences of waste. Likewise, scientific research contributes to ecologically favourable technological advancements in waste treatment. Though science raises public awareness about an environmental issue, public attention can either encourage or discourage scientific research on the subject to gain political support.

If more individuals are worried about a certain environmental issue, more researchers will research it. In addition, politicians and private companies may provide more financial support to facilitate studies that look into issues that are more intimately tied to them. Because of the scientific determinant in waste management, this thesis will demonstrate how scientific influences can help improve solid waste management in Freetown Central One Zone.

1.8. Research Hypothesis

SWM's main goal is to decrease or eliminate the negative effects of waste materials on human health and the environment, as well as to support the pillars of sustainability by combining circular economics for development and improved quality of life. To save money and avoid waste buildup, this should be done in the most resourceful way possible.

A hypothesis is a proposed explanation by a researcher based on a specific indication from a beginning point for further investigation. This study hypothesized the following

for an examination of environmental effectiveness and community participation in enhancing a sustainable municipal solid waste management practice in Freetown:

- 1) There is a nexus between “environmental effectiveness”, and “community participation in enhancing a sustainable municipal solid waste management practice,
- 2) There exists a strong positive correlation between population growth and environmental degradation due to increasing waste generation,
- 3) The lifestyle of households, demographic setting and perceived standardization can influence the type of waste and quantity produced,
- 4) There is a positive relation between imbalanced cultural brought-up and improper waste management practices, poor sanitation and poor health of people. That is, human health is related to the indoor and outdoor environment,
- 5) Flooding in most of the major streets within the Central One Zone is not unconnected to improper and unscientific management of solid waste.

1.9. Concept and Definition of Solid Waste

The terms solid wastes have been defined in works of literature by several authors. According to [29], Solid Waste represents anything that is neither liquid nor gas and is discarded as unwanted by the producer. In the same way, some literature such as Open Wash [30, 31] define solid waste, as all the wastes arising from human and animal activities that are generally solid and are cast off as unusable or unwanted by the person or organization that produces it.

Rendering by [7, 32, 33], municipal solid waste (MSW) is defined as a waste type that comprises principally household waste (domestic waste) with sometimes the addition of commercial wastes collected by a municipality within a given area. Similarly, municipal solid wastes are wastes that result from municipal services such as street sweeping, dead animals, market waste and institutional wastes that are not hazardous. However, solid waste does not comprise solid or dissolved materials in domestic sewage or other significant pollutants in water resources, such as silt, dissolved or suspended solids in industrial wastewater effluents, dissolved materials in irrigation return flow or other common water pollutants.

1.9.1. Solid Waste Management System

Tchobanoglous and Kreith [34] explained solid waste management as the discipline connected with the control of generation, storage, collection, transfer and transport, processing and disposal of waste in a manner that is in accordance with best principles of public health, economics and that is also responsive to public attitudes.

1.9.2. Composition, Quantity and Characteristics of Municipal Solid Waste

Many pieces of literature have addressed the challenge of

managing solid waste. The composition, characterization and quantity of solid waste generation are fundamentally dependent on the type of environmental activity, and even the monetary status of individuals in the community. According to Chandrappa and Das, [35] handling solid waste is one of the indispensable services which frequently fails due to swift urbanization along with variations in the waste quantity and configuration. The quantity and composition of municipal solid waste differ from country to country, and the amount of municipal waste produced from an urban settlement is a function of several factors such as; human development index (HDI), education indices and gross domestic product.

Above and beyond, the quantity of solid waste hangs on different occasions like sports events, festivals, conferences, elections, social mayhem and industrial strike action. Mostly, the quantity of MSW is invariably higher and complex in the developed countries equated to the developing countries [35]. Urban solid wastes can be broadly subdivided into two most important components; Biodegradable and Non-Biodegradable. The biodegradable constituent of urban solid waste constitutes an organic matter, which under controlled environments, can be turned into compost or organic fertilizer. Whereas, the non-biodegradable waste comprises inorganic materials that cannot be easily putrefied and degraded. Non-biodegradable waste is classified as either recyclable or nonrecyclable.

1.9.3. Classification of Solid Waste

Solid waste, ranges from; original use, material, physical properties, safety characteristics to Human waste etc. Also, it is important to review the various types of waste since there are numerous ways to categorize them. Apart from the physical characteristics of waste (solid or liquid). Since this research looks at solid waste, an account of liquid waste is not considered in this research. These wastes may not have the same intrinsic constituents and environmental impacts. As such, it is necessary to elucidate their differences: Human Waste- these wastes comprise excreted materials by the human body and are often recognized as body by-products of digestion such as faeces and urine [36]. Municipal Waste-as is a combination of waste from households, office buildings, street sweepings, litter, and market refuse, institutions and small businesses, yards and gardens, that is collected and treated by the municipalities/metropolitan, sillage-according to Wisner and Adams,[36], describe it as a composition of wastewater from kitchens, bathrooms and laundries. It can contain disease-causing organisms, especially from soiled clothing, Hazardous Waste-involves materials that pose considerable threats to public health and/or the environment. Such materials are often labelled as; corrosive, ignitable, reactive, or explosive warning, flammable, caution, poisonous, toxic etc. They could exist in any of the states of matter (liquid, solid or gaseous). These wastes should be considered hazardous as

they have the propensity to cause long-term risk to health and /or the environment.

1.9.4. Waste as a Part of Nature: Past and Present

Given our present standpoint on waste as a problem, it is fascinating to note that waste has always been a natural part of past ecosystems. Waste has always existed, and it has been produced by all living things on Earth. Nevertheless, nothing was wasted in the natural system that is characterized by ecological synchronization and circulation. Waste was naturally converted into a useful organic resource for other organisms in the circular process of nature.

1.9.5. Waste Becoming an Environmental Problem

According to the World Bank's estimations, "world cities annually produce approximately 1.3 billion tons of solid waste" [1, 4, 37] This makes waste become a serious social and environmental issue, qualifying it now as a waste crisis. Furthermore, the World Bank estimates that by 2025, annual solid waste production will exceed 2.2 billion tons. This waste crisis has emanated from three principal factors; mass consumption, technological advances, and changes in people's behaviour in consumption and waste disposal practices.

1.9.6. Solid Waste Generation

Solid waste generation differs for different cities, municipalities and countries, especially in developing countries. One vital necessity in waste management is the provision of an accurate record of waste generation in terms of quantity and composition. This allows the management actors to handle the amount and various categories of waste generated effectively. Waste generation is a natural product of three key elements; urbanization, economic development, and population growth. As nations and cities become more populated and prosperous, more products and services are offered to citizens and participate in global trade and exchange. They face a corresponding increase in the amounts of waste to manage through treatment and disposal. The world generates 0.74 kilograms of waste per capita per day, yet national waste generation rates fluctuate widely from 0.11 to 4.54 kilograms per capita per day [1, 8]. Waste generation volumes are usually correlated with income levels and urbanization rates. An estimated 2.01 billion tonnes of municipal solid waste were generated in 2016, and this number is expected to grow to 3.40 billion tonnes by 2050 (figure 2) under a business-as-usual scenario [38, 39]. The total quantity of waste generated in low-income countries is expected to increase by more than three times by 2050.

Presently, the East Asia and Pacific region are generating most of the world's waste, while the Middle East and North Africa region are producing the least in absolute terms (figure 2).

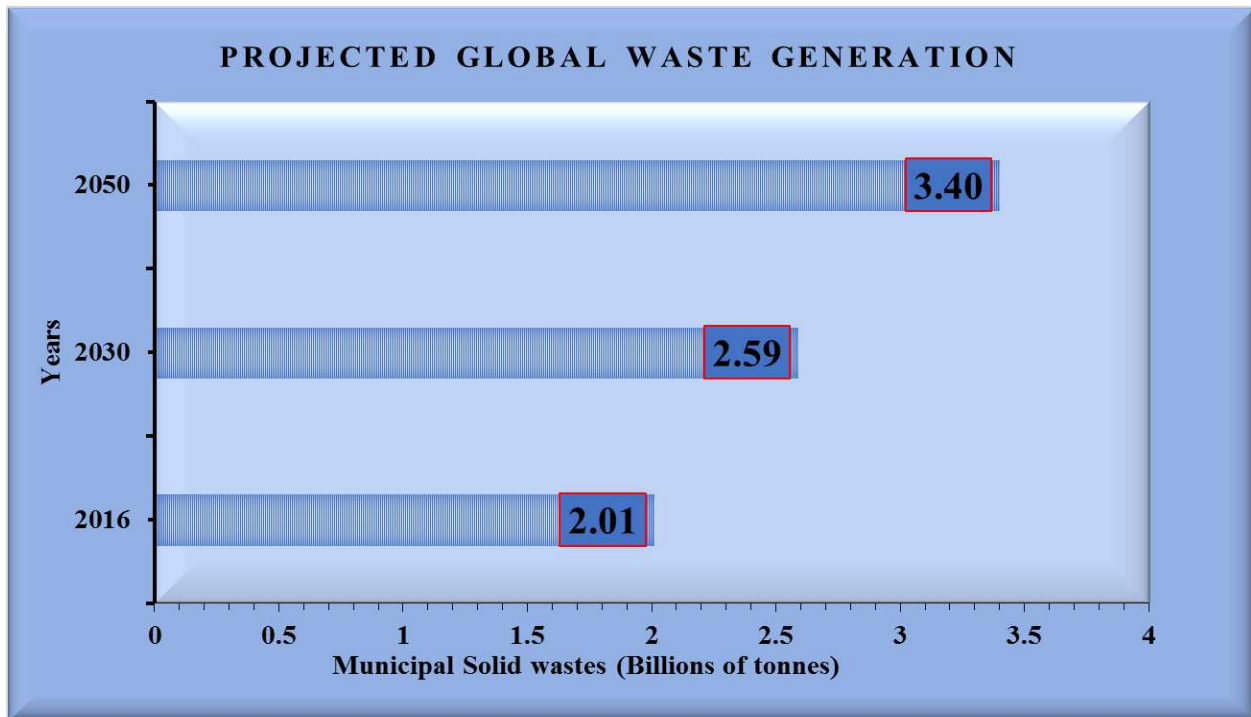


Figure 2. Projected Global Waste Generation up to 2050. Source: World Bank Group, “What a waste 2.0”. A Global Snapshot of Solid Waste Management to 2050. Chart slightly modified the author.



Figure 3. Quantity of Waste Generated by Major Regions of the World. Source: World Bank Group, “What a waste 2.0”. A Global Snapshot of Solid Waste Management. Chart slightly modified the author.

Average waste generation across countries varies substantially, from 0.11 kilograms per capita per day to 4.54 kilograms per capita per day. Waste generation has an overall positive relationship with economic development (figure 3). It is hard to get waste generation statistics in quantities and composition for all the countries in the region [3].

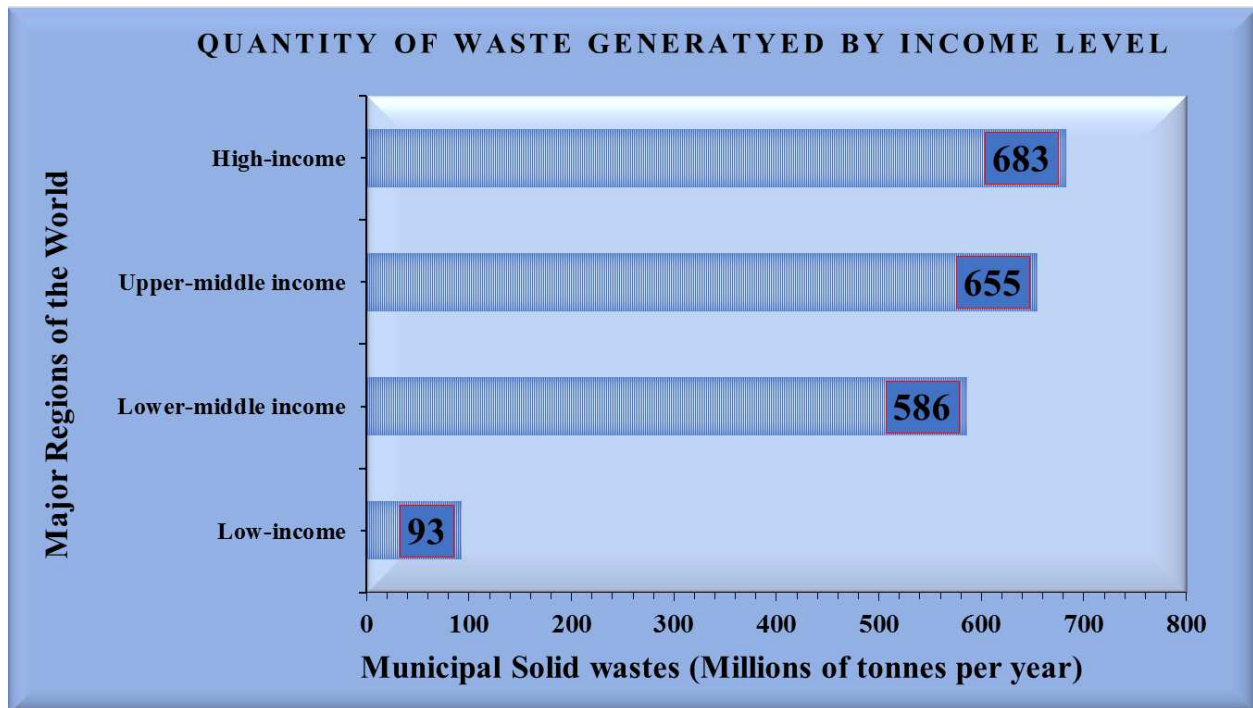


Figure 4. Quantity of Waste Generated by Income Level on a Global Perspective. Source: World Bank Group, "What a waste 2.0". A Global Snapshot of Solid Waste Management. Chart slightly modified the author.

1.9.7. Solid Waste Collection and Management

At the municipal level, waste collection is one of the most common services provided by waste management stakeholders. Quite a lot of waste collection service models are used across the globe. The most common form of waste collection is a door-to-door collection. In this model; trucks, small vehicles or, where environments are more constrained, handcarts or donkeys are used to collect garbage outside of households at a predetermined regularity. In certain localities, communities may discard waste in a central container or collection point where it is picked up by the municipality and transported to final disposal sites. In other areas with less regular collection, communities may be notified through a bell or other signal that a collection vehicle has arrived in the neighbourhood. This is a common practice in remote places.

According to some literature and academic scholars [4, 5], management of waste entails the collection, transportation, recovery, and disposal of waste, as well as the monitoring of such operations and the maintenance of disposal sites, as well as acts conducted as a dealer or broker. This implies a series of activities (figure 4) that run from the collection, transport, treatment and disposal of waste, to control, monitoring and regulation of the production, collection, transport, treatment and disposal of waste.

Even though society has an intrinsic waste management system, the management can create a serious problem for the environment and people if the main technique for waste disposal is landfilling. Landfills have been criticized as one of the causative mechanisms of global warming and climate change due to the emission of a massive amount of methane into the air [6]. Aside from creating environmental problems,

a landfill gives rise to negative impacts on human life and the environmental aesthetic by being a potential place to spread disease due to its unsanitary conditions, and by creating a terrible odour on the landfill sites.

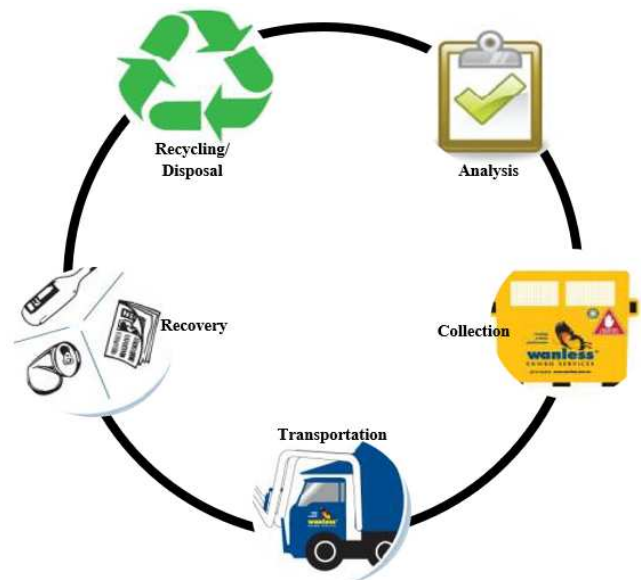


Figure 5. A Typical Waste Management Flow Cycle.

2. Materials and Methods

2.1. Location of the Study Area

The study area is Freetown Western Urban, the capital city of Sierra Leone. It is located at 8.48° N and 13.23° W along the Atlantic coast of West Africa on a funnel-shaped igneous

intrusion [7, 8]. Freetown was founded on 11th March 1792 with a total area of 357 square kilometres. It has an estimated

population of 1,055,964 and has a varied distribution pattern according to age groups.

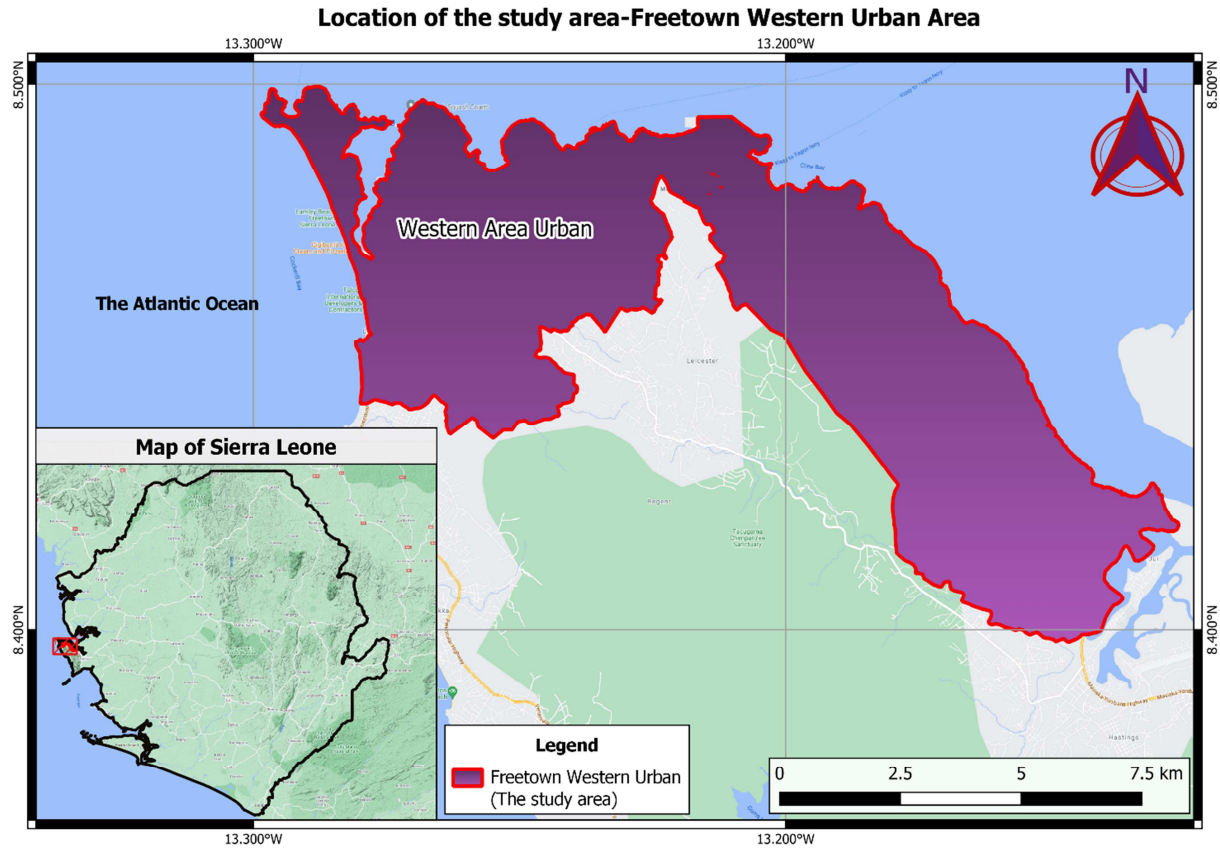


Figure 6. Location of the Study area in Sierra Leone.

2.2. Investigative Technique

This study fundamentally took on a cross-sectional descriptive survey design and employed both quantitative and qualitative research approaches. The qualitative data was used to enhance the descriptions of the quantitative data to fully examine the environmental effectiveness of Freetown Western Urban Area waste management.

2.2.1. Sample Size Determination

Several mathematical models [46–48] have been in use to compute and determine the suitable sample size for either a finite or an infinite population. In this study, Cochran [11] mathematical model for the infinite population was used to estimate the sample size (n) of households to participate in the study (equation 1).

$$n = \frac{z^2 PQ}{e^2} \quad (1)$$

Equation 1 Cochran's infinite Sample Size (n) determination.

Where:

n = sample size of household heads and respondents;

Z = Standardized normal variable and value that corresponds to 95% confidence interval equal to 1.96;

$Q = 1 - P$;

e = Allowable/acceptable level of sampling error (margin of error typically $0.05\% \pm 5\%$);

P = Sample proportion (the most conservative value, 50%; i.e., 0.5 by default).

Scholars such as Dilma and Wang et al., [49, 50], have stated that no absolute rules exist about the number of participants in social surveys, as it is contingent on the needed margin of error and confidence. Different methods have been applied by scholars to maximize the response rate of the questionnaire, which include: phone conversations, online-based interviews, face-to-face interviews, and postal service [14] etc. In this study, the target population was surveyed through the use of an electronic questionnaire.

2.2.2. Target Population and Sampling Approach

Adult residents aged fifteen (15) years and above residing in Freetown Western Urban Area were targeted, as they were matured enough to make a coherent decision about the existing environmental effectiveness of solid waste in the study area. In addition, this target population exhibit varied demographic characteristics. The study area was stratified into five layers according to the degree of an active-age group, community service/participation, sensitivity and responsive nature to environmental effectiveness on SWM. The central Zone was chosen because it is a middle-income zone.

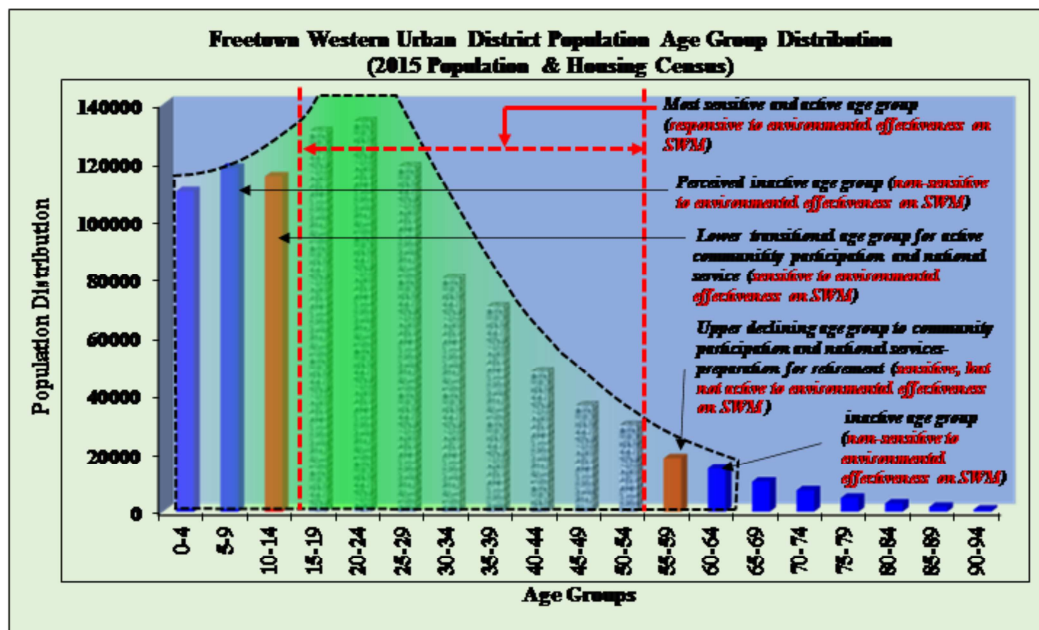


Figure 7. Freetown Western Urban Area Age Distribution Pattern based on 2015 Population & Housing Census. Data Source: (Stats SL Final Summary Results, 2015). Chart by the author.

3. Results and Discussions

Demographic Characteristics and Respondents' Profile

The target population size for the study was 384. In total, 280 electronic questionnaires were given to them. However, only 265 were utilized to conduct the overall analysis of the data, the remaining was turned down owing to substantial abnormalities and inconsistencies. There were 265 people who responded, and this accounted for a 94.6% response rate of the questionnaires that were given to the population of

interest. A response rate of 94.6% is equitably good and statistically accepted to give a satisfactory result in a cross-sectional investigation.

The demographic statistics show that there were more women (54%) than men (46%) and that the majority of them are between the ages of 26-35 and 15-25 respectively. Concerning employment status, 41% of the participants have businesses of their own. According to the statistics, 20% of the population was unemployed, 14% and 15% are in private and government employment correspondingly.

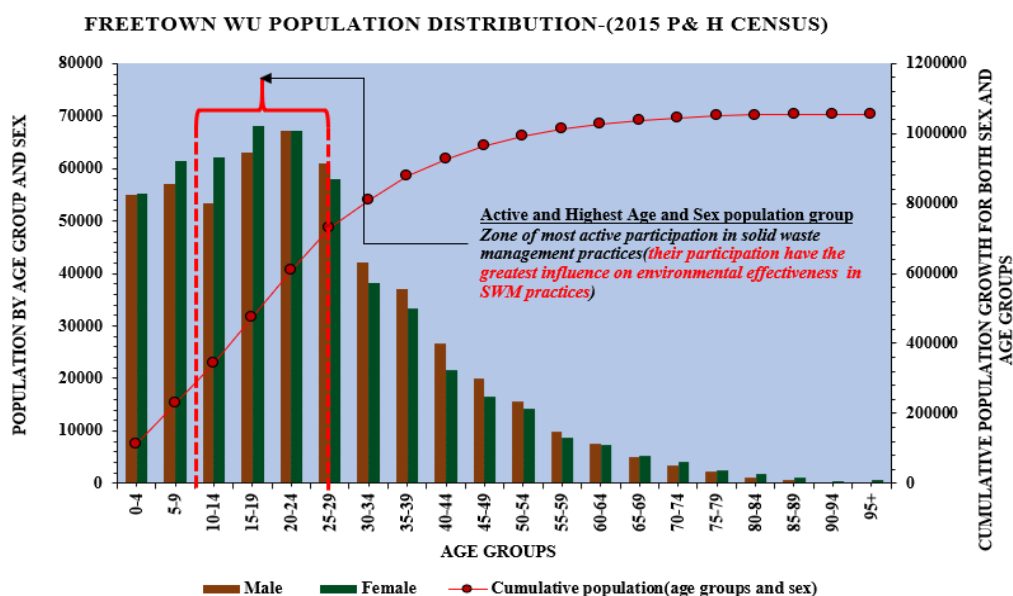


Figure 8. Age Groups and Sex population Distribution pattern of the study area based on the 2015 Census of Population and Housing. The authors of this project created the chart. (Stats SL Final summary Results, 2015) is the data source.

The results from the survey show an implied influence of the role of sex's participation on the environmental effectiveness of SWM in the study area. Since there are more females than males, and they spend so much time at home, where 95 percent of household waste is generated, indicates that the majority of female inhabitants are either unconcerned about the impact of solid waste or unwilling to participate in odd duties like communal waste management. However, at the household level, the smallest unit of the community, females show a high sensitivity to SWM and thus, invariably keep their households hygienic and healthy. So it becomes glaring that the role of sex has a resonating influence on how effective the community will respond to SWM.

Residents are the prime producers of waste in all forms, beginning in the kitchen as the local setting for waste production, and then moving on to the community. Consequently, the awareness of sustainably segregate and

dispose of waste at the household level is very significant to the environmental effectiveness of waste management. This is true because, when that knowledge is applied daily, it saves time at the dumps. Drawing a pragmatic assertion to this end about the participation of community residents in the direction of SWM, the survey questionnaire infused some waste management-related questions.

As per the survey's findings, 60 percent of those that participated in the survey have heard of managing solid waste. Furthermore, it was alleged by 70% of the respondents that the Freetown Waste Management Councils had never provided any system of training on the appropriate disposal of solid waste. Therefore, it suggests that solid waste management is ineffective at the institutional level, which is one of the determinants of effectiveness in my conceptual framework.

Table 1. Residents' answers to two knowledge-based questions on SWMP. Data from the authors' survey.

| Question types on SWMP | Questions | Response | Frequency | Percentage |
|---|------------|----------|-----------|------------|
| Do you know or are aware of what solid waste management is? | Question 1 | Yes | 155 | 57 |
| | | No | 118 | 43 |
| Has the Freetown Waste Management Council ever educated you on appropriate solid waste disposal techniques? | Question 2 | Yes | 97 | 36 |
| | | No | 174 | 64 |

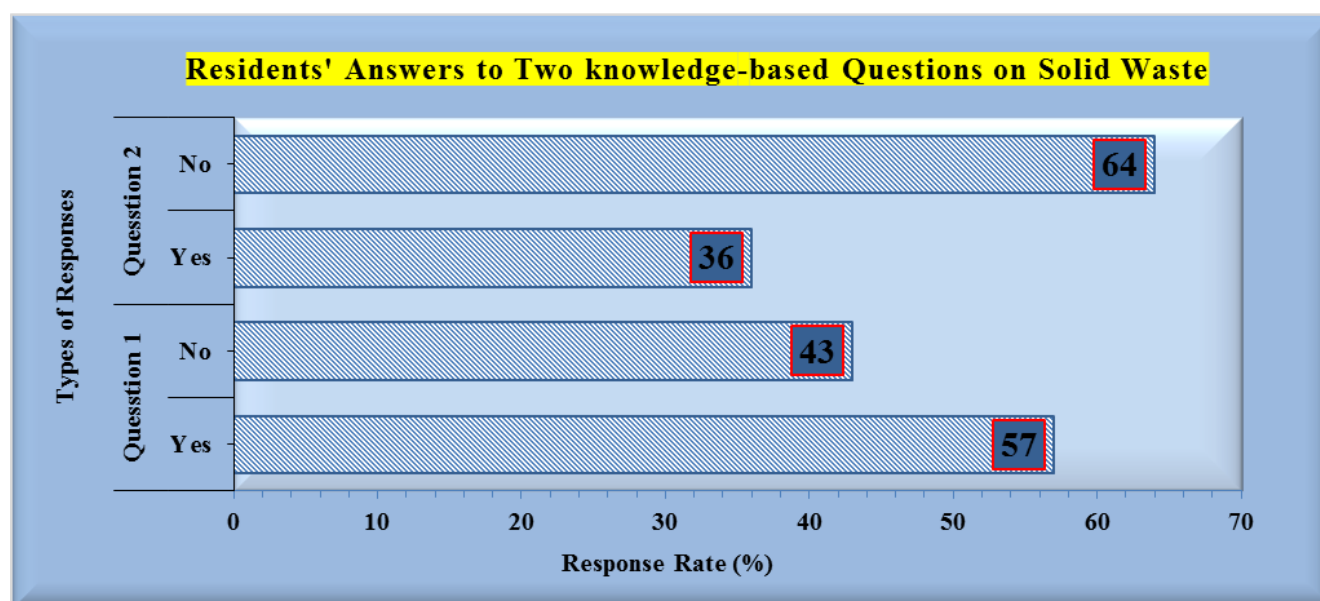


Figure 9. Residents' Knowledge-based Questions and Answers on Solid Waste Management. Data from the authors' survey.

Furthermore, the findings revealed that waste sorting at the source level is a stern issue in the study area. Residents in the study area do not give waste a bare minimum sorting before transfer and ultimate disposal. This invariably creates an immense chore at the dumps. This is a crucial environmental problem regarding SWM in Freetown, and it is palpable from the bad conditions of almost all the dumps in the city. Several households have been utilizing self-supplied waste containers, which are frequently insufficient and unsuitable for temporarily storing their generated waste materials. (*a lack of the economic arm-determinant of effectiveness*). The

situation is exacerbated when rubbish is seen haphazardly scattered on the ground creating difficulty for waste collection services to gather. Some respondents based this dilemma on a lack of separate garbage disposal containers, while others said they were too busy to segregate their generated waste. As a result, they just dispose of rubbish indiscriminately, which is considered an environmentally inefficient method of solid waste management practice. This infers that residents are aware of what to do with the solid waste they generate. They do, however, lack the science of solid waste disposal that is environmentally friendly.

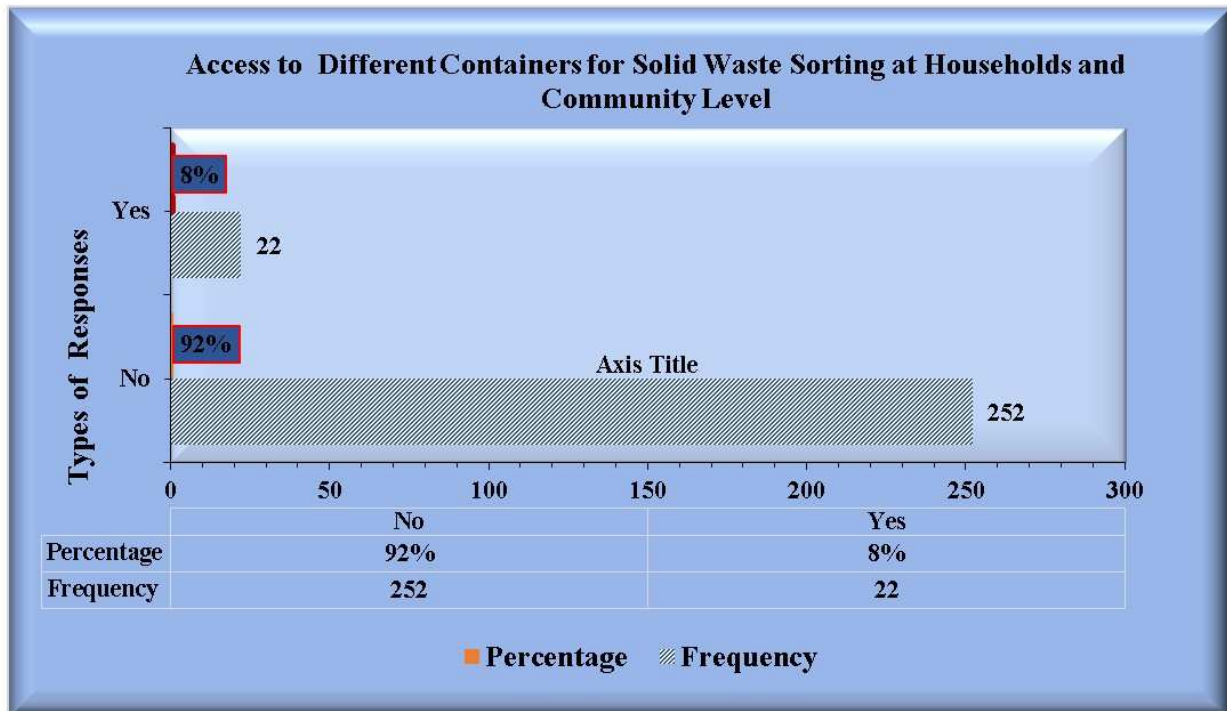


Figure 10. Respondents Access to Sorting Facilities at Household and Community Level Collection Services. Source: Author's survey data 2021.

4. Conclusions

In this research, community participation in enhancing sustainable management practice of solid waste disposal was completed utilizing the four determinants of environmental effectiveness as a conceptual framework from Kutting's studies. Kutting examined the role of international environmental agreements in amending environmental hitches by using regulatory structures, time, economic structures, and science as determinants. Although my research findings differ slightly from Kutting's conclusions on the indications to look for when determining how effective the environment should be in managing solid waste management, there are notable parallels. The perceived implications of the influence of community participation on solid waste management have indeed been addressed using this paradigm of environmental. An android-based electronic questionnaire was used in the investigation to obtain data from residents in the Freetown municipality.

From the initial hypotheses presented on the "*examination of environmental effectiveness and community participation in enhancing a sustainable municipal solid waste management practice in Freetown*", based on the undermentioned conclusions, analyses of the findings have properly confirmed the assertion of the following initial hypotheses and the major goal of this study:

- 1) Residents in the study area have an understanding of what SWM is, and the impacts of its ineffectiveness on the environment. Almost, all the residents regardless of their economic level agreed that indiscriminate disposal of waste may levy an irreversible impact on human

health and renders the environment unappealingly horrendous. This aspect of this study ties well with one of the determinants- the irreversibility of time. Furthermore, time, as one of the most important factors of environmental effectiveness, has a broad impact on the gap between the amount of waste generated and the amount of waste collected in the study area. It takes a much smaller time for a large volume of waste to be filed up, but a much longer time for waste collection service providers to collect the generated waste (figure 1). This constitutes regulatory and time ineffectiveness for any sustainable SWMP. According to similar research, approximately 45 % of the total solid waste generated in Freetown have not been effectively collected. Where does the uncollected waste sit in the management hierarchy; for example, could be an instigating question one may ask of the generated solid waste by households and commercial-related activities? The authors of this research hold the opinion that the uncollected waste is left indiscriminately dispersed along waysides, uncompleted structures, on-street, gullies and open-yards etc. Rapid population growth in Freetown City following the end of Sierra Leone's 11-year civil war, unbalanced cultural upbringing, household lifestyle, demographic environment, and perceived standardization are all factors that can significantly influence the type and quantity of solid waste generated. Time, like its counterpart determinants, has a profound impact on how solid waste is treated sustainably.

- 2) Time is vital at an institutional regulatory and scientific level for enhancing a sustainable SWMP, as it recounts

the irreversibility of damage to the environment. By time frames, waste actors can take correct and pressing actions to regulate continuing environmental hitches. Furthermore, time is critical because most policies and/or programs require a long time to develop and implement. In summary, novel policies, regulations and proposed development may not be made in a short period.

- 3) However, even though residents are aware of the precarious nature of solid waste, how waste is managed show environmental effectiveness in all ramifications. This is due to the failure of integration and practicalizing the four determinants of environmental effectiveness. In practice, these four determinants may not require equal weighting with their application for any sustainable SWM, but they need absolute inclusion at all stages in the waste management hierarchy.
- 4) Similarly, the mainstream of household residents within the study area believe that the Freetown Waste Management Council must provide free moveable skip containers for their communities. This may suggest the reasons some residents had, and continue to dispose of solid waste indiscriminately. Nonetheless, some of the residents, both at the community and family levels, expressed their dissuasion to such unscientific practices. The Freetown Waste Management practice is based on the least desired approach on the waste management hierarchy, rather than the most preferred and desired approach that encourages the circular-economy paradigm. The waste management hierarchy provides the best modular approach for environmental effectiveness and sustainability for municipal solid waste management practice. Therefore, any attempt to practice the least preferred option of the waste management hierarchy will invariably result in environmental ineffectiveness. And this is the situation and practice of the Freetown Waste Management council and other solid waste collection agencies. It is manifested in the lack of one or more of the determinants that measure effectiveness.

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