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## Policy Dynamics and Innovations in Solid Waste Management in Nigeria: Assessing the Initiatives of Lagos State Government

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### ABSTRACT

Addressing the problems of solid waste requires the development and implementation of holistic and integrated waste management policy and initiatives that consider environmental, social and economic impact. Contemporary waste management policies need to prioritize recycling and provide proper infrastructure for waste reduction, collection, sorting, treatment and re-use. This current study analysed the innovative policies and dynamic initiatives of the Lagos state government on solid waste management to ascertain their effectiveness. The study adopted a survey design and drew its inferences from the responses of 285 participants drawn from different MDAs connected to waste management in Lagos State. The data were analysed using a Chi-square statistical method of analysis. Findings revealed that Waste Recycling have an impact on Waste Reduction in Lagos State. The study also found the establishment of the incineration power plant to be significantly impactful to the 'waste-to-energy' initiative. The study concluded that waste management in Lagos State government has deployed modern technological innovations for effective waste management. The establishment of a materials recovery/recycling facility has significantly influenced the waste-to-energy initiative. The study, however, made suggestions that could further enhance solid waste management policy in Nigeria using Lagos State as a reference point.

ncineration, waste management, policy initiative, recycling, collaboration

### Introduction

Throughout history, human advancement has been intrinsically linked to the management of solid waste due to its effect on both public and environmental health. Nigeria's Constitution recognized the importance of environmental safety; therefore, Section 20 empowered every state to protect the environment. There are also Acts of the National Assembly that have been promulgated by the National Assembly towards guaranteeing environmental safety. These Acts at the Federal level include the Federal Environmental Protection Agency

(FEPA) Act of 1988 repealed by the National Environmental Standard Regulation Agency (NESREA) Act, of 2007. Other regulations were made under the FEPA Act including the National Environmental Protection

(Management of Solid and Hazardous Wastes) Regulations (Maduka, 2017)

The Acts were promulgated to save our environment and reduce pollution. However, Nigeria's major urban areas are today fighting to clear mounting heaps of solid waste from their environments. Cities that were once known for beautiful aesthetics, peace and security have been overtaken by the messy nature of over-flowing dump sites, and unattended heaps of solid waste that are emanating from households, markets, businesses, shopping centres and industrial waste. The available city waste managers seem incapable of having absolute control of the undesirable situation. The unlawful and haphazard dumping of hazardous commercial and industrial wastes has a grievous impact on air, water and the environment and grossly violates

environmental sanitation laws, rules and regulations (Nkwachukwu, Chidi & Charles, 2010).

Solid waste management (SWM) has a long and convoluted history (Mingaleva, Natalia, Irina & Tatiana, 2020). Systems of Solid Waste Management can trace their root back to ancient times. One of the first instances of waste management occurred in the 4th century A.D. with the Ancient Greeks. United States Department of Agriculture Rural Information Center (USDARIC, 2021) reported that solid waste disposal is a major concern in rural areas. The report further stated where and how to begin SWM has been a major concern for all communities especially, rural communities.

Solid waste and its management challenges have become recurring features in our urban environment. It is no longer in doubt that Nigerian cities are inundated with the challenges of uncleared solid wastes. As a result, urban area residents are often confronted with the dangerous impact on their collective health and safety. (Adeniyi, Akinpelu, Fatoke & Adeniji, 2022). The mountainous heaps of solid waste that deface urban cities in Nigeria and the continuous discharge of industrial waste into streams and rivers resulting in contamination and pollution motivated the Federal Government of Nigeria to promulgate Decree 58 for the establishment of the Federal Environmental Protection Agency (FEPA) on 30 December 1988 (Adegoke, Ogundairo, Olukanni, & Olofinnade, 2019).

Despite the formulation of FEPA and a national environmental policy, the environment has not been adequately protected, Interest is mainly in aesthetics, which is rarely achieved (Fajonyomi, Ajulor & Ibikunle, 2020). Wastes collection is irregular and restricted to the major cities. Improperly sited open dumps deface several cities, thereby endangering public health by encouraging the spread of odours and diseases, uncontrolled recycling of contaminated goods and pollution of water sources (Adegoke et al., 2019). Presently, the solid waste management system in Nigeria is very inefficient, inept and largely unsustainable. This is because, waste

management is characterized by inadequate waste management facilities, poor access to waste collection and management services, and inconsiderable level of generated waste collection and waste disposal that do not to standard global practice. Indiscriminate disposal of solid waste has had grievous consequences on infrastructural facilities among which are blockage of sewers and drainage networks, and eutrophication and choking of water bodies. States in Nigeria are yet to develop effective solid waste management policies "only fragmented and un-harmonised waste management laws exist" (National Policy on Solid Waste Management, 2020: 10). Given these challenges, the Federal Government attempted to develop National Policy on Solid Waste Management System. The Policy aims, among others, to promote a clean and healthy environment for sustainable socio-economic development of the nation; develop waste management infrastructures; promoting the reuse, reduce, recycle and recovery initiatives. Notably, the policy aims to promote private-sector investments in solid waste management.

The integral aspect of the National Policy on Solid Waste Management is the integrated solid waste management (ISM) initiative. ISM comprises:

Strategies and methods to be adopted in promoting effective handling of solid waste through a comprehensive approach. Solid waste management is a complex task that depends largely on organization and cooperation between households, communities, private enterprises, industry and municipal authorities, as well as the selection and application of appropriate technical solutions for waste generation, handling/sorting, storage, collection, transportation, transfer, treatment and disposal. Various agencies are increasingly becoming active in the management of solid waste including Federal/State/Local governments, private sector, NGOs and various forms of public-private partnerships resulting in pilot projects and programmes." (National Policy on Solid Waste Management, 2020: 10).

An integrated system that will provide a holistic framework for the scale-up of these activities to create a country-wide impact is very necessary but still lacking. Lagos is relatively the second most populated state in Nigeria, according to the National Census (2006), and administrations have already created many waste management systems over the years. It is an undeniable fact that Lagos governments have been fighting solid waste for several decades, and policies, strategies, and techniques have been proposed. However, there has not been a lot of success. It was in this context that this study was designed to examine public policy and solid waste management in another perspective.

### Statement of the Problem

Increased urbanization and frequent environmental sanitation exercises made urban residents dump solid wastes carelessly or haphazardly anywhere they deem fit. Over time, these indiscriminately disposed solid wastes in the street turn some parts of the street into dumpsites. During the dry season, winds flap these wastes and litter the streets and environment. During the rainy season, rainwater carries the wastes in the streets into the drainage and roads and blocks the roads and the drainage, thus causing flooding, which has been of serious challenge in Lagos State. The flood sometimes overflows into people's homes, destroying lives and properties. Again, indiscriminate dumping of wastes makes the environment dirty and serves as a breeding site for disease-causing organisms

As a coastal fast-developing megacity, Lagos has a landmass of 3,345 km<sup>2</sup> with an estimated population of over 20 million people. These people reside and do business in Lagos. There is also a high influx of people from every walk of life resulting in an overwhelming increase in population. The attendant effect of increased population is an increase in the amount of waste generation. According to Adeyemo (2019), about 10000 metric tonnes of waste is being generated in Lagos per day and they were mostly landfilled. Aside, from the health and environmental hazard of the uncontrolled emission of greenhouse gas such as methane

CH<sub>4</sub> into the atmosphere, waste and waste management has become a huge burden to the state government, corporate organisations as well as households. The failure of relevant policies to stem the tide of reckless waste dumping and littering of Nigerian cities' infrastructure (streets and roads) and surrounding bushes indicates a clear pattern of non-enforcement or non-implementation of existing environmental sanitation laws.

Gross violations of relevant rules and regulations continue to hinder plan preparations and effective incineration. Studies have been carried out on the irregular and indiscriminate dumping of solid wastes and the waste disposal policy of the government (Azodo, 2020; Olukanmi, Adeleke & Aremu, 2016; Abass, 2014). However, less attention is paid to innovation, policy formulation, execution and implementation by scholars. Hence, this current study was conceived with a clear objective to analyze the current policy on Solid Waste Management strategies with particular reference to Lagos State. The study's specific objectives are to: (i) evaluate the influence of waste disposal innovative strategy on waste to wealth in Lagos State and (ii) to examine the effect of waste recycling and up-cycling on waste reduction strategy in Lagos State. Lagos, as a sub-national in the forefront of creating models for waste management through its various policy initiatives and programmes like circular economy, waste-to-wealth and waste-to-energy, public private initiative to waste-management is pioneering the move towards a resourceful and waste free economy. Hence, the choice of Lagos State as case in point for this study.

### Conceptual Review

It is essential to analyse and, as well, operationalise the major concepts that are relevant to this article for better understanding. These concepts include; innovation, recycling, up-cycling, incineration and public policy were defined, operationalized and applied to the present study. Reviewed literature showed different perspectives of innovation on solid waste management. Most of these perspectives are technological, policy and regulatory, social,

collaborative, digital-driven, behavioural and so on.

## Solid Waste Management and Policy

Solid waste management has become a major concern in environmental issues (Cainelli, D'Amato & Mazzanti, 2015). This is particularly true in urban areas where the population is rapidly growing and the amount of waste generated is increasing like never before (Rahman, Myrna & Karlina, 2020; Rachna & Sharma, 2022). Effective waste management is a condition for environmental sustainability depending on policy guidelines (Azodo, 2020). It expresses Nigeria's sense of duty regarding sustainable development about the efficient management of the environment (Ikpeze, 2019). Therefore, waste is the birthplace of environmental issues, and as would be seen underneath, the regulatory system for environmental protection here has gotten attention in Nigeria based on the number of agencies involved (Ikpeze, 2019). However, what remains oblique is, can the regulatory system in Nigeria attend to the challenges postured by the increasing rate of waste generation. There are numerous laws and agencies regulating waste management in Nigeria. These comprise The National Environmental Standards Regulatory and Enforcement Agency (NESREA); Federal Ministry of Environment; States' Ministries of Environment; Ministry of Water Resources; Lagos State Waste Management Authority (LAWMA) and different states' waste management experts; States' Environmental Protection Agencies, for example, the Lagos State Environmental Protection Agency (LASEPA); and States' Waste Disposal Boards, for example, the Lagos State Waste disposal board (LSWDB). Bako (2019) stated that Laws/Regulations on Environmental Management in Nigeria are glued on the 1989 National Policy on the Environment as edited in 1998, and likewise, a set of laws, regulations, and guidelines to guarantee the preservation of natural resources and the quality assurance of the environmental and human wellbeing.

The objective of the Nigeria Government Policy on waste management is to

accomplish sustainable development in Nigeria to secure a quality environment for Nigerians sufficient for their well-being and prosperity; re-establish, keep up and upgrade the ecosystems and ecological procedures key for the role of the biosphere to save biological diversity and the standard of ideal sustainable yield in the utilization of these natural resources and ecosystems; sharpen public awareness and raise comprehension of crucial linkages amongst environment and development in environmental improvement efforts (Adeyemo, 2019). Likewise, to collaborate with other countries and international organizations to accomplish the ideal utilization of transboundary natural resources and successful counteractive action against transboundary environmental pollution (Bako, 2019).

The Federal Environmental Protection Agency (FEPA) Act is the major legal framework for waste management in Nigeria. With the change to democratic governance in 1999, FEPA transformed into the Federal Ministry of Environment in June 1999. As a ministry is to a greater extent, a policy-making organ, the Federal Government built up in November 2006 the National Environmental Standards and Regulations Enforcement Agency (NESREA) with powers the same with the old FEPA for effective enforcement of environmental regulations in Nigeria. All FEPA laws have been abrogated with the NESRA Act signed into law by the President of Nigeria in July 2007. The federal laws are the minimum standards in the states. Constitution 33 permits the state to set up stricter standards for waste management and also enforce stiffer sanctions on violators of waste disposal regulations than the Federal (Bako, 2019).

## Innovation in Solid Waste Management Processes

Globally, there are standard as well as innovative practices for solid waste management. Some of these practices are identified and discussed as follows:

### *a. Incineration*

Solid waste is incinerated or disposed of in landfills and gas is extracted from the waste, which is then converted to electrical energy



(Gumbo, 2014). The greenhouse gases emitted during the energy-generation process from the waste are recycled in the process which aids in reducing ORG's into the atmosphere. This technology is more viable than the burning of fossil fuels such as coal which release carbon dioxide into the atmosphere (Hamer, 2003).

#### **b. Gasification**

Solid waste is heated at a temperature of above 1000°C in a gasifier, in an atmosphere starved of oxygen to have an incomplete combustion of the waste. A gas called syngas is produced which can be used as a fuel (Nhubu & Muzenda, 2019). The gas is made up mostly of carbon monoxide, hydrogen and methane. The exact composition of the gas is influenced by the air, temperature and water content which can be changed to yield the required gas composition. In South Africa there are no such plants but a few exist in the world (Nhubu & Muzenda, 2019). Combustible waste- refuse-derived fuel is produced thermally via a mechanical pre-treatment method suitable for general waste, from this process pellets are produced and can be used as fuel in approved facilities (Ruwona, Danha, & Muzenda, 2019). The RDF process produces higher quality fuel products with a higher calorific value than the initial waste and they are easy to use, transport and handle. Even though there are several RDF plants in the world, none have been erected in South Africa (Nhubu & Muzenda, 2020).

#### **c. Landfill Gas**

A liquefied petroleum gas (LPG) plant consists of an extraction system and a utilization system. The extraction system usually consists of vertical perforated pipes, horizontal perforated pipes and in some cases a membrane covering under which the produced gas is collected (Willumsen, 2019). Gas is sucked out of the landfill through a pump or a compressor leading the gas into the production system. The gas is commonly used as fuel in a gas engine running an electric generator. It can be used in a gas boiler to produce hot water for heating (Daskalopoulos, 2019). Under normal circumstances, the gas is not purified but if the gas is to be used in a gas boiler or gas engine impurities are removed. In other cases, the gas is upgraded to almost pure

methane which is then used in the natural gas network (Willumsen, 2019). An example that has embraced innovative technologies to convert waste into energy is the EThekweni municipality located in Kwa-Zulu Natal province (Gumbo, 2019), Gas collector wells are drilled into the mount in the landfill to suck the gas that is transported to all the pipes to the gas pump and flare station.

- d. **Waste-to-wealth Initiative:** Lagos has emerged as a Circular Economy Hotspot in Africa (Thisday, 2023). The initiative become operational in Lagos through it enabling law i.e. Lagos State Employment Trust Fund Law 2016. The law aims to provide financial support to residents of Lagos State, for job, wealth creation and to generate employment through the use of waste either for recycling or up-cycling.
- e. **Recycling:** This describes the transforming waste resources into new materials and things is known as recycling. This notion frequently includes the recovery of energy from waste materials. The ability of a material to regain the attributes it had in its original state determines its recyclability. It is an alternative to "traditional" garbage disposal that can assist in saving material and reducing greenhouse gas emissions.
- f. **Up-cycling:** Up-cycling is another component of the recycling process. Most recycling is about changing or taking away valuable parts from a product and making a new product or material out of them. Up-cycling connotes taking waste and creating something new from it even in the waste current state. In up-cycling, the original form is retained and the object is recognisable, which gives it a story; one can obviously see the object's old form and also what the transformation it has undergone.

It is important to state that possible benefits of innovations in Waste-to-energy are indeed a necessity as they will enhance the quality of life, ensuring a decrease in illegal dumping sites and a decrease in the use of landfill sites which are the main cause of climate change (Mazhandu, et al., 2020). Waste-to-energy will also address the issue of land scarcity for landfill sites as fewer landfill sites will be needed. It will promote the transfer of pollutants from one medium to another.

Energy waste will also lead to waste minimization and will promote the development of pollution prevention technologies (Brunner & Rechberger, 2019). It will ultimately promote the effective use of energy, materials and resources (Mazhandu, et al., 2020). Every solution does however have certain challenges which are discussed next.

## **Lagos State Waste Management Authority**

The Lagos Waste Management Authority (LAWMA) is a parastatal of the government of Lagos State responsible for managing waste generated in Lagos State through a waste collection, transportation and disposal structure. The goal of the Lagos State Waste Management Authority (LAWMA) is to improve the environment with the impact of achieving positive and significant changes in living conditions regarding health and sanitation (Adeyemo, 2019).

The Lagos State Refuse Disposal Board (LSRDB) was instituted under Edict No. 9 of 1977, which was the first of its kind in West Africa. The Board has the responsibilities of environmental sanitation and domestic refuse collection and disposal in Lagos State. The Board was renamed the Lagos State Waste Management Authority via the enactment of a new Law Edict No. 55 of 1991, which conferred on the Authority additional responsibilities for the collection and disposal of municipal and industrial wastes as well as the provision of commercial waste services to the State and Local Governments of Lagos State (Ayantoyinbo & Adepoju, 2018).

The Board metamorphosed over the years into the agency known today as the Lagos Waste Management Authority (LAWMA) by the LAWMA Law 2007 and accrued added responsibilities. These responsibilities include management of commercial, industrial, and medical waste streams, highway sanitation, cleaning of drainage and other water bodies, to construction and demolition of waste management, among others. LAWMA works closely with the Lagos State Ministry of Environment and has initiated reforms regarding the collection of waste bills and

also aims to increase waste recycling. LAWMA's areas of focus as highlighted by Adeyemo (2019) are as follows:

- Domestic waste collection carried out under a PPP franchise
- Public waste collection and Street washing
- Commercial Waste collection
- Medical (hazardous) Waste Collection: provision of safety boxes
- Market Waste collection
- School Waste Collection
- Street sweeping of litter, silts and abandoned tires
- Local Policing
- Marine Waste collection covering the shorelines of the state
- Public Awareness and Education: –on –one Advocacy & print & electronic media
- Monitoring & Evaluation
- Enforcement
- Recycling
- Landfill Management
- Transfer Loading Station (TLS) Management

In summary, LAWMA drives the waste management initiative of the Lagos State Government through policy dialogues, capacity building benchmarking, and practices to facilitate enhanced awareness raising. The institution develops work plans aimed at facilitating the implementation of integrated solid waste management at local, state, and national to promote public health, economic efficiency and rapid reduction in waste generation and increase in waste utilization. LAWMA applies one or combinations of the following strategies:

- Close cooperation between the public and private sector
- Single point of contact for all International partners regarding waste
- Management in Lagos State.
- Extensive market information and export channels
- Local knowledge and networks
- Sustainable Resources i.e. Local workforce, ideas

## **Theoretical Discourse: Theory of Reasoned Action.**

The Theory of Reasoned Action (TRA) was postulated in 1975 by Fishbein and Ajzen to explain and predict human

behaviour. The TRA posits that a person's intention to perform a specific behaviour is a function of two factors: attitude (positive or negative) toward the behaviour and the influence of the social environment (general subjective norms) on the behaviour and that the attitude toward the behaviour is determined by the person belief that a given outcome will occur if s/he performs the behaviour and by an evaluation of the outcome (Jacobsen, Pedersen, & Thøgersen, 2022). The theory examines the relationship between attitudes and behaviour. TRA focuses on behavioural intentions instead of attitude as predictors of behaviour. According to this theory attitude (positive or negative) toward the behaviour is determined by the person's belief that a given outcome will occur if he or she performs the behaviour and by an evaluation of the outcome (Jacobsen, Pedersen, & Thøgersen, 2022; Dhir, Koshta, Goyal, Sakashita & Almotairi, 2021).

According to the proponents of the theory, behaviour is largely influenced of the social environment (general subjective norms). While the Theory of Reasoned Action has provided valuable insights into understanding behaviour, it is important to recognize its limitations which stem from difficulty Measuring attitudes, norms, and intentions can be challenging. The theory is applied to the study such that solid waste management is influenced by the solid waste managers' attitude and social environment. The solid waste managers' attitude towards solid waste management is guided by their belief and evaluation of the effects of solid waste management on health and the environment. If they believe that ineffective solid waste management will adversely affect health and the environment, they will be motivated to be committed to solid waste management. This is because if Lagos State Refuse Disposal Board (LSRDB) staffs efforts are not supported by LAWMA staff and vice visa, example: if LSWDB maps out dumpsites and LAWMA staff do not comply, solid waste management will be ineffective in the State.

## Empirical Review

In this section, the study reviews certain empirical studies that have relative significance to this study. For instance, Dilly

(2020) conducted a survey study on solid waste management practices in U.S. Army medical treatment facilities (MTFs). The objective of the study was to survey solid waste management practices, participation in waste reduction and recycling programs, and solid waste management problems in 25 MTFs. The study adopted the descriptive research design. The population for the study consisted of 25 medical treatment facilities (MTFs). A questionnaire was modified to survey solid waste management practices, participation in waste reduction and recycling programs, and solid waste management problems. A sample of Eighteen MTFs randomly selected from the 25 MTFs participated in the study. Data collected were analyzed using means. The mean importance ratings of waste reduction and recycling were 2.00 and 1.83 (1 = very important; 5 very unimportant), respectively. Results revealed that twelve MTFs used contractors to disinfect potentially infectious solid waste off-site. Limited staffing was ranked as the most significant waste management problem, followed by cost and regulatory compliance. The study, therefore, recommends that more information on waste generation in MTFs is needed. Regardless of the importance of this study, it is limited in scope, in the sense that it concentrated on medical waste and waste management problems only without any strategy for improving them. This current study is a deviation from the status quo in essence that it shifted emphasis from problem of waste generation and waste problem to analysis of policy initiatives and innovations vis-à-vis their impact.

Ehienemo (2019) carried out a study on solid waste management practices in tertiary and secondary-level hospitals in Enugu Urban. The objective of the study was to investigate solid waste management in tertiary and secondary level hospitals in Enugu urban and the basis for designing a Safer Sharps management intervention programme. The study utilized the descriptive research design. The population for the study consisted of thousand six hundred and thirty-seven (1,637) clinical solid waste generators and handlers from tertiary and secondary level hospitals in Enugu urban. The sample for the study was three hundred (300) clinical solid waste generators

and handlers selected from the thousand six hundred and thirty-seven tertiary and secondary level hospitals in Enugu urban registered tertiary and secondary level hospitals in Enugu urban. Quantitative data were collected from three hundred solid waste generators and handlers, Qualitative data were collected through direct observation and interviews of fifty-four-unit heads. Twenty-five item Solid Waste Management Practices Questionnaire (SWMPQ), eleven item Solid Waste Management Practices Observation Performa (SWMPOP), and thirteen-item Safer Sharps Management Intervention Programme Evaluation Questionnaire (SSMIPEQ) were the instruments for data collection. The collected data were analyzed using frequencies, and percentages. Four null hypotheses formulated for the study were tested at a 0.05 level of significance using chi-square statistics.

A descriptive research survey was conducted by Abass (2014) on solid waste management techniques in urban areas of Ekiti State. The study assessed solid waste management techniques in Ekiti State urban areas. The descriptive survey research method was used in the study. The population of the study consisted of all the residents in urban areas of Ekiti State. The sample for the study was 1500 urban residents drawn from a random selection of LGA headquarters. Six hypotheses were formulated for the study and tested at a 0.05 level of significance. The results obtained revealed among others that there was indiscriminate dumping of solid waste in urban areas and recommends, among others, that environmental sanitation should be improved in urban areas with the provision of adequate dump sites; refuse vans and environmental sanitation personnel, coupled with effective implementation of environmental policies.

Azodo (2020) carried out a study on the management of solid waste in Nigeria: challenges and solutions using descriptive research design. The objective of the study was to identify the methods for the storage of solid wastes, ascertain the waste disposal systems, and determine the effective waste management system. The population for the study was 2000 (Anambra State Waste

Management Authority, ASWAMA-1200 and Enugu State Waste Management Authority, ESWAMA-8000). A sample size of 333 comprised of 200 ASWAMA and 133 ESWAMA obtained using Taro Yamane's statistical formula was used for the study. Observation schedule, interview and questionnaire served as the instruments for data collection. Data obtained were analyzed using frequencies and percentages. The hypotheses formulated were tested using the Chi-square statistic. The result obtained indicated that financial constraints and lack of appropriate technologies are the major challenges to waste management. The study concludes that successful waste management depends on adequate financing, enabling legislation and a supporting institutional and policy environment. The study, therefore, recommends a holistic program which will integrate all the technical, economic, social, cultural and psychological factors that are often ignored in solid waste management.

Fajonyomi, Ibikunle and Ajulor (2021) conducted a study on the spatial location of solid waste dumpsites and collection scheduling using the geographic information systems in Lagos metropolis, Nigeria. The objective of the study was to examine the application of Geographic Information Systems in determining the spatial location of solid waste dump sites and collection schedules. The study revealed that the average household size is 9; daily solid waste generated per household is 6.11kg; and per person is 0.80kg. While 40% of the solid wastes generated are managed by LAWMA, 30% are indiscriminately dumped in unauthorized spots in the area. The study in line with the outcome of a study conducted in the Bauchi metropolis by Barambu, Maigari & Sulaiman (2020) recommends the employment of the integrated solid waste management system that requires geospatial information if sustainable solid waste management in urban areas is to be achieved. The study is quite important but it is limited geographically. This present study will bridge this gap and extend to rural areas.

Hammed, Scidhar and Wahab (2016) conducted a critical assessment of waste management problems in the Ibadan South-West Local Government Area of Oyo State



in Nigeria. The descriptive research survey design was adopted for the study. The population for the study consisted of all the residents of the community. The sample for the study was 200 participants drawn from five political wards using a simple random sampling technique with replacement. Six hypotheses were postulated to guide the study. The questionnaire served as the instrument for data collection. Data collected for the study were subjected to descriptive statistics using frequency and percentages of the responses. The responses were graded as follows for computation purposes; strongly Agree = 1, Agree = 2, Disagree = 3, Strongly Disagree = 4. The relationship between the observed variables and the waste management problem as a constant was analyzed using Pearson Product Moment Correlation. The results further revealed that the area suffered waste management problems due to a lack of proper physical town planning and a lack of adequate funding to support the poor environmental state of health of the community. The study, therefore, recommended that the concerned authorities should take note of the six factors highlighted in the study and also effect necessary changes to mitigate the effects of these problems. Although this study is significant, it only concentrated on the residents who may not do much as far as solid waste management is concerned. Given this, the present study focused on the role of solid waste management agencies.

## Research Design

This study adopts a survey research design which involved the collection of data through the use of a questionnaire as an instrument. The research instrument was administered to several respondents. A descriptive survey research design was used because it helps the authors to describe the situation in its real context. With the use of a descriptive survey, the authors were able to make inferences about the relationship between variables without direct interference and involvement from concomitant variations of the variables involved. It also helps to make valid conclusions about the population. The information surveys provide is useful in solving local problems. Surveys may be qualitative or quantitative in the verbal or mathematical form of expression;

such studies are factual and hence supply practical information (Salaria, 2012).

## The population of the Study

The population for the study comprised two hundred and eighty-five (285) workers in Lagos State Waste Management Authority (LAWMA). Records drawn from LAWMA Head Office, Ijora were used to estimate the population of SWM workers in Lagos State. This includes two hundred and eighty-five (285) LAWMA staff.

## Sample size and Sampling Techniques

The sample size is a smaller representative of a larger whole or a fraction or part of the whole. Sampling can also be described as a process or procedure of selecting part of the entire population for observation for an effective administration of the questionnaire. From the total population of 285 employees of Lagos State Waste Management Authority, the sample size was 166. The Sample size was determined using the Taro Yamane formula which states as follows:

$$N = \frac{N}{1 + N(e)^2}$$

Where: n = Sample size

N = Population

e = Level of precision or Sampling of Error of  $\pm 5\%$

$$n = \frac{285}{1 + 285(0.05)^2}$$

$$n = \frac{285}{1 + 0.713}$$

$$n = \frac{285}{1.713} = 166.4 \text{ sample size}$$

## Method of Data Collection

This section outlined the methods that were used to collect primary data which was the use of a questionnaire. The primary research data was collected using a semi-structured questionnaire. Items in the questionnaire were arranged in a logical sequence according to the themes being studied and items that would elicit similar responses were grouped. The questionnaire has both closed and open-ended, predetermined and standardized sets of questions. The questionnaire was considered to be one of the most appropriate instruments for survey research. Hence, a structured questionnaire, which consists of closed-ended questions, was used. The five-point type rating scale was used in measuring responses to the questions. Five points rating

scale gives respondents a chance to express their views independently.

### Hypotheses Statement, Testing and Analysis

The methods of analysing the data collected for this research work involves Chi-square ( $X^2$ ) test. This study was guided by two hypotheses as follows:

**Hypothesis One:** that there is no significant effect between innovation on waste and waste management in Lagos State.

To test hypothesis (i) above, the Chi-square test of goodness of fit was adopted. The formula for the calculation of X is given as

$$X^2 = \frac{\Sigma(O-E)^2}{E}$$

Where

$X^2$  = Chi-square

O = the observed Frequency

E = the expected Frequency

$\Sigma$  = Summation

### Contingency Table

	SA	A	UD	SD	D	TOTAL
2	56	48	9	30	23	166
5	75	30	10	25	26	166
	131	78	19	55	49	332

### Chi-square Cross Tabulation

Responses	O <sub>i</sub>	E <sub>i</sub>	(O <sub>i</sub> - E <sub>i</sub> )	(O <sub>i</sub> - E <sub>i</sub> ) <sup>2</sup>
Strongly Agreed	131	33.2	97.8	9564.84
Agreed	78	33.2	44.8	2007.04
Undecided	19	33.2	-14.2	-201.64
Strongly Disagreed	55	33.2	21.8	475.24
Disagreed	49	33.2	15.8	249.64
<b>TOTAL</b>	<b>332</b>			
				<b><math>X^2C = 376.43</math></b>

The degree of freedom for the Chi-Square test of Goodness of fit is given as: (r-1)

Where:

r = no rows

DF = (r-1)(c-1)

DF = (4-1)(5-1)

DF = 3 x 4

At 1 2df and seemed 50% (0.5) level to significant Chi- Tabulated ( $X^2t$ ) is

21.026 1 = 21.03

**Decision Rule:** When the Chi- Square calculated ( $X^2C$ ) is great then Chi- Square tabulated ( $X^2t$ ) we reject the null hypothesis

(Ho) and accept the alternate hypothesis Hi and conclude that the research hypothesis is true i.e.  $X^2c > X$ . We conclude that the research hypothesis false.

**Hypothesis Two:** There is no significant effect between Waste Recycling and Waste Reduction Strategy.

To test the above hypothesis we shall employ the chi-square test of goodness of fit. The formula for the calculation of  $X^2$  is given as

$$X^2 = \frac{\Sigma(O-E)^2}{E}$$

Where:

$X^2$  = Chi-square

O = The observed Frequency

E = The expected Frequency

$\Sigma$  = Summation.

	SA	A	UD	SD	D	TOTAL
2	75	29	11	20	31	166
5	24	25	19	54	44	166
	99	54	30	74	71	332

### Contingency Table Chi-square Cross Tabulation

	Response E <sub>i</sub>	O <sub>i</sub>	E <sub>i</sub>	(O <sub>i</sub> - E <sub>i</sub> )	(O <sub>i</sub> - E <sub>i</sub> ) <sup>2</sup>	(O <sub>i</sub> - E <sub>i</sub> ) <sup>2</sup> E
2	Strongly Agreed	99	33.2	65.8	4329.64	130.41
5	Agreed	54	33.2	20.8	432.64	13.03
6	Undecided	30	33.2	-3.2	-10.24	0.31
14	Strongly Disagreed	74	33.2	40.8	1664.64	50.13
7	Disagreed	71	33.2	37.8	1428.84	43.03
	<b>TOTAL</b>	<b>332</b>				<b>236.91</b>

$X^2C = 236.91$

The degree of freedom for the Chi-Square test of Goodness of fit is given as: (r-1) where:

r = no rows

DF = (r-1)(c-1)

DF = (4-1)(5-1)

DF = 3 x 4

At 1 2df and steemed 50% (0.5) level to significant Chi- Tabulated ( $X^2t$ ) is

21.026 1 = 21.03

### Decision Rule

When the Chi-Square calculated ( $X^2C$ ) is great then Chi-Square tabulated ( $X^2t$ ) we

reject the null hypothesis ( $H_0$ ) accept the alternate hypothesis  $H_1$  and conclude that the research hypothesis is true i.e.  $X^2_c > X^2$ . On the other hand, if the Chi-square calculated is less than the Chi-Square tabulated ( $X^2_t$ ) i.e.  $< X^2_t$ . We conclude that the research hypothesis false

### Findings and Discussion

Upon the application of the Chi-square formula, the calculated ( $X^2_c$ ) is greater than the tabulated  $X^2_t$ , therefore, we rejected the null hypothesis and accept the alternate hypothesis. We, therefore, concluded that there is a significant effect between innovation on waste and waste management in Lagos State. Secondly, we reject the null hypothesis and accept the alternate hypothesis and conclude that waste recycling has a significant effect on waste reduction. Hence, the two research hypotheses were rejected and alternative hypotheses were considered valid

Following the results of the tests, some findings seem to establish a relationship between innovation and waste management in Lagos State. This means that waste management in Lagos State has enjoyed the usefulness of new technology and also makes use of the new equipment for effective waste management when we considered the operations of LAWMA in Lagos State. This finding is consistent with those of other earlier studies (Adeyemo, 2019; Ayantoyinbo & Adepoju, 2018) that have established effectiveness in the operations of LAWMA in Lagos based on certain dynamics and innovations that characterize their operations.

Looking at the second hypothesis, there is a significant effect between Waste Recycling and Waste Reduction Strategy. This also shows that the efficient recycling system leads to waste reduction on the street of Lagos and also ensure a tidy environment which also reduces some pollution that affects human health and it creates wealth for State Government while the Private organization in Waste reduction also benefits from too. The study also found out that the procurement of a new incinerator power plant by the Lagos State government has positively impacted the waste-to-energy

programme and the establishment of a materials recovery/recycling facility has tremendous influence on waste-to-energy creation. It has also aided the production of energy as a source of income for the state government. In tandem with the findings on medical-waste-to-energy design made by Chen, Li, Li, Xu, Jin, Wang, & Liu, (2022), the result demonstrates that the waste-to-energy initiative is more efficient, economically feasible, and ecologically friendly. Similarly, the finding match those observed in earlier a study (Ukpanyang, Terrados-Cepeda & Hermoso-Orzaez, 2022) that reveals that the gasification technology in waste to energy outperformed the other innovations in the provision of electricity in slums considering the amount of waste being generated.

Waste recycling and its likely effects on the health, quality of the environment and the urban landscape have become burning national issues in Nigeria today. The safety and the beautification of our environment have come to realize the negative consequences of unclear solid human wastes found in residential neighbourhoods, markets, schools, and central business districts in our cities. These solid wastes have become recurring features in our urban environment.

### Conclusion

Solid waste is incinerated or disposed of in landfills and gas is extracted from the waste, which is then converted to electrical energy. Solid waste is heated at a temperature of above 1000C in a gasifier, in an atmosphere starved of oxygen to have an incomplete combustion of the waste. A gas called syngas is produced which can be used as a fuel (Pilusa & Muzenda, 2020; Nkosi, Muzenda, Zvimba & Pilusa, 2013). The gas is made up mostly of carbon monoxide, hydrogen and methane. An incinerator plant consists of an extraction system and a utilization system. The extraction system usually consists of vertical perforated pipes, horizontal perforated pipes and in some cases a membrane covering under which the produced gas is collected (Mazhandu, et al., 2020).

It can be concluded that waste management in Lagos State has deployed modern technological tools and also makes use of the new equipment for effective waste management. The establishment of a materials recovery/recycling facility has significantly influenced the waste-to-energy initiative and aid the production of energy as a source of income for the State government.

## Recommendations

Although Lagos State Government has developed good private sector participation, the partnership can still leverage the strengths of both parties to create sustainable and efficient waste management solutions. Especially to jointly design, finance, build, operate, and maintain waste management infrastructure. This can include waste collection, sorting, recycling facilities, waste-to-energy plants, and landfill management. PPPs can allocate risks and responsibilities while utilizing private sector expertise and resources.

More so, governments can provide financial incentives or subsidies to private companies that invest in innovative waste management technologies and processes. This can encourage private sector involvement in recycling, composting, waste-to-energy projects, and other sustainable waste management initiatives. Collaboration can extend to research and development projects aimed at finding new and improved waste management technologies. The government can provide funding and support for research, and private companies can contribute expertise and resources to develop innovative solutions for waste reduction, recycling, and waste treatment.

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The following recommendations would positively impact the waste management by the appropriate authority in Lagos State:

- i. Needs to do more to create awareness of, and encourage waste minimization techniques in manufacturing processes, procurements, product utilization and waste management processes to reduce. It is only through this means that everyone can be better informed to avoid indiscriminate dumping and assist with planning for effective and sustainable solid waste management.
- ii. LAWMA should develop effective waste sorting methodologies. The initiatives may be backed by appropriate incentives to motivate the public on the need to sort their waste in line with the provisions of the state's waste management board.
- iii. Community participation and involvement in decision-making, planning, implementation, and evaluation of waste management activities will instigate behavioural change and help in developing good knowledge and skills related to waste management.
- iv. The Government should embrace Smart waste management initiation. Smart waste management describes a system that uses technology for refuse collection. It is capital-intensive but economically viable in the long run. The user-friendly systems are usually fortified with Internet of Things (IoT) facilities. Equipment like artificial intelligence recycling robots is already in use in developed climes.
- v. Ultimately, successful collaboration between the government and the private sector requires open communication, shared goals, and a commitment to environmentally responsible waste management practices.

Finally, researchers, as well as practitioners, should now begin to explore more how solid waste recycling and conversion strategies could be effectively optimized.



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