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APPRAISAL OF THE PERFORMANCE OF WASTE MANAGEMENT AGENCIES IN NIGERIA WITH A VIEW TO INTRODUCING SMART MANAGEMENT TECHNOLOGIES

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Abstract: This study examined the appraisal of the performance of waste management agencies in Nigeria with a view to introducing smart management technologies. To carry out this assessment, three objectives were drawn up those covers; examining the subsisting solid waste management methods; looking into the existing operational management techniques and also exploring applicable smart technologies in the management of solid waste in Nigeria. The methodology isolated three LGAs (Asaba, Warri and Ughelli) in Delta State, Nigeria with a study population of 675,149 through purposive sampling technique and applied the Slovin's sample size determinant formula to determine a sample size of 400 respondents who received structured survey questionnaires. Using percentages, tables and pie charts to analyze the data, pops up some findings in the area of overcrowded households of 6-8 persons (33%) in a room putting pressure on services such as solid waste management, and poor facilities, 47.3% making management efforts complex. In the summary of the empirical review, it was observed also that in Kano (Northern Nigeria), 79.25% respondents dispose waste in unauthorized dumpsites and 68% complained of poor collection by agencies. Hence, the recommendation for improved seamless management processes in the area of adequate funding, capacity building and provision of up-to-date facilities. More profoundly, it is expected that the smart technologies and supporting ICT infrastructure could address the critical areas of waste management which includes but not limited to funding, and capacity building in the waste management value chain in Nigeria.

Keywords: Agencies, Management, Smart, Technologies, Waste

1.0 Introduction

The World Bank since 2000 has committed $4.7 billion in more than 340 solid waste management programs in 6 regions of the world concerning World Bank engagements, most of those affected are in developing countries like Nigeria, making solid waste management (SWM) a serious concern. It is estimated that Nigeria generates an average of between 32-42 million tons of waste annually out of which only 20-30% is collected and properly disposed. Hence, Chinedu, et, al. (2018) argues on the need for a robust data-base and other efforts for effective solid waste management. In Nigeria waste management is characterized by inefficient coverage of collection system and improper disposal by overwhelmed waste management Agencies suffocated by management challenges at the Federal, States and Local government levels. Statutorily, the institutional framework of waste management in Nigeria is hemmed around public institutions such as Federal Ministry of Housing and Environment, National Oil Spill Detection and Response Agency, National Environmental Standards Regulations and Enforcement Agency, etc at the Federal Level; State Ministries of Environment, Waste management agencies at State Level and waste management authorities at Local Level (Oloko, 2021).

As urban populations continue to grow, some cities are struggling to cope. Many are turning to new technologies and innovations for cost-effective solutions to clean up waste (Lewis, 2019). Reflectively, Padilla, (2017), affirms that with strained budgets and growing populations, being smarter about all aspects of waste management is becoming a growing priority. For instance, smart technologies reduce operational costs by identifying inefficiencies and streamlining operations (Mavropoulos, 2017). According to Aleyadeh & Taha, (2018), the use of emerging technology may lead to significant improvement in the waste management processes. In the same line of thinking, Saha, Auddy, Pal, Kumar, Pandey, Singh, Singh, Banergee, Ghosh and Saha, (2017), argues that integrated hardware and software solution optimizes waste collection, saving time, money and the environment.
This seminar paper is meant to develop a management framework for SWM agencies based on the use of smart technology as a management template "integrating different technologies such as IoT, cloud computing, mobile computing, pervasive computing and wireless sensor network. The design system is tailored to support and optimize waste management operation and the system uses a single metric data acquired from recycle bin which indicates level of waste in the bin and when filled triggers a beeping sound in the central control system manned by the Waste Management Agency and connected to the mobile sets of operating staff who acts on the reminder signal from the control room" (Idowu, 2012). It is noteworthy that this paper is emphasizing for the use of special waste collection vehicles with in-built can crushers, wood grinders and shredders to reduce the volume of transportable waste and for secondary usage (Sahu, *et al*, 2020). Godfrey (2019) reflected that the available evidence in the African continent suggests that the current poor state of SWM amongst others is largely due to failures in governance and organizational weaknesses resulting in poor service delivery and a perceived high risk for private sector investors in SMW.

1.2 Statement of the Problem

Why is it that the SWM Agencies in Nigeria have not been able to put forward a management framework that understand the dynamics of waste and its management to minimize human and environmental concerns? This question lays the foundation for the statement of the problem this research is seeking answers to through the objectives and research questions. In reviewing current methods of waste management by the agencies responsible shows inefficiency at its height in that most of the methods and equipment deployed are obsolete and analogue no more in tune with current reality of waste management in the 21st century. For instance, open trucks popularly described as tippers are still used today to transport solid waste to dumpsites. The agencies should acquire bullock trucks with compressing technology. Saha , Auddy, Pal, Kumar, Pandey, Singh, Singh, Banergee, Ghosh and Saha, (2017),argues that integrated hardware and software solution optimizes waste collection, saving time, money and the environment. The agencies management mechanism today lacks capacity building in the area of modern techniques in solid waste management. There is the need for proper skill acquisition and retooling of workers in the management spectrum to allow for up-to-date knowledge in the handling of solid waste management challenges.

1.3 Aim and Objectives of the Study

The study broadly examine the appraise performance of waste management agencies in Nigeria and to explore the implication of the use of smart technologies in waste management. However, the specific objectives are:

i. To ascertain the relationship between Government Support and the various methods of solid waste management in Nigeria.
ii. To assess the effect the existing operational management techniques in solid waste management in Nigeria.
iii. To assess the effect of the application of smart technologies in the management of solid waste in Nigeria.

1.4 **Hypotheses of the study**

i. There is no relationship between Government Support and the various methods of solid waste management in Nigeria.

ii. Existing operational management techniques has no effect on the solid waste management in Nigeria.
iii. Application of smart technologies has no effect on the management of solid waste in Nigeria.

Review of Related Literature

2.1 Conceptual Review

Waste Management (W.M) Agencies

These are usually appendages of government structure with the usual bureaucracies statutorily empowered to carryout waste management in their respective domain. These organs of governance carryout their activities with a well- articulated administrative and legal framework. This is the nucleus of the research connecting all the various arteries be it technologies or funding, facilities, capacity building, political will, etc.

Government Support

The government at all levels is responsible for establishing the institutional and legal framework for waste management. In other words, it is the government that provides funds, equipment, staff and all that is necessary for the agencies to carry out their activities.

Private Sector Investment

These are private investors normally engaged by Agencies in most developing countries they go by different descriptions such as Private Sector Participant (PSPs) or Public Private Participants (PPP) as in India. Non-governmental organizations (NGOs) operate between the private and government realms, to increase the capacity of people or community groups.

Methods of Solid Waste Management in Nigeria.

The disposal of solid waste generated in most Nigeria is generally administered by one or more of six methods. All are currently in use in one degree or another in various parts of the world. To a large extent, the method of waste management in any particular area depends upon local conditions and, to some extent, public attitude. It is noteworthy that each has its unique relation to the water resources of the area. Six general or conventional methods of waste management are employed. These include: -

i. Open Dump
ii. Sanitary Landfill
iii. Incineration
iv. Onsite Disposal
v. Feeding of Garbage to swine
vi. Compositing
vii. Recycling

Operational Management Techniques in the Management of Solid Waste in Nigeria

There is no doubt the various current methods of solid waste management in use in Nigeria have become inadequate with the astronomical rise in population and increase in urbanization. This is evidenced by the inability of waste management agencies to cope with the management of the attendant waste build-up from human activities that has seriously compromised the environment in all ramifications. The old methods of waste collection and disposal have become insufficient to deal with the rising of waste generation that now calls for more advanced methods of management in the realms of technologies. Therefore, the introduction of the use of technologies has become sacrosanct to handle the activities of various human and environmental services which include but not limited to solid waste management. Hence solid waste management applications such as waste level bin sensors, smart bullock trucks, robotics, etc. help to create efficiency and cost effectiveness in the solid waste management value chain.

Technologies

These are systems that uses technology to make waste collection and disposal more efficient, cost-effective and environmentally friendly. Therefore, smart technologies in waste management connotes, solving waste management problems using sensors, intelligent monitoring systems and mobile applications. Most of these

systems are equipped with Internet of Things (IoT), a monitoring technology that collects and tracks real-time data to help optimize waste collection. A good example of smart technologies is, smart waste bin, waste level sensors, solar powered truck compactors, etc.

Smart Technology Efficiency in Waste Management in Nigeria.

The era of smart waste management using smart technologies is now overdue, due to rising urbanization challenges and the astronomical rise in population figures compromising environmental management modalities. Since smart technologies are now becoming part of our everyday lives, their application in the collection and transportation of waste has become more of a reality. Smart technologies are really about connectivity and exist today in collection, transfer, processing and disposal operations. Better location-based data, reliable networks, and faster microprocessors have made routing solutions much faster and smarter (Ross, 2017).

Implementing smarter waste collection, waste segregation, and disposal solutions can lead to more environmentally friendly cities (Phoenix Energy, 2018). Some of the popular and emerging smart waste management technologies that can be adopted to enhance efficiency in solid waste management in the area of study are identified as follows: -

*"*Ultrasonic trash can sensor*- An ultrasonic trash can sensor regularly informs you on how full your waste container. This aids in reducing the cost that accompanies overfilling a dumpster.

****Solar-powered trash compactor*-** A solar-powered waste compactor is a smart device that reads a waste bin's fill-level in real-time and triggers automatic compaction of the waste, effectively increasing the bin's capacity by up to 5-8 times.

****Image-based trash can sensor*-** Image-based trash can sensor is GPS based and automatically monitor fullness and contents. It also determines which containers need service each day, then schedules routes and evenly distributes jobs to drivers.

****Instant payment in return for e-waste*-** This technology proposes instant payment for electronic waste devices. It is a convenient option to dispose of gadgets like smartphones and tablets from landfills and later be recycled or refurbished.

****Waste management apps*-** Waste management companies have developed apps which help manage waste efficiently and in an environmentally friendly way. Apps such as Sitebuddy and Toogood Togo are a few examples of revolutionary waste management apps "(Compactor, 2021).

Implications

The implications of the use of smart technologies for waste management which affects both the actors and recipients has to do with the numerous 'benefits' in the area of efficiency, simplified processes and saner human environment with better living and working conditions. Some of the implications of smart waste management are-

Economic Implications

a. Reduce collection frequency by effectively increasing capacity by up to 8 times.
b. It uses real time data to optimize resource allocation
c. Lowers operational cost up to 80%
d. Capacity building

Social Implications

a. Improves public cleanliness
b. Stimulates the green technology industry and the use of renewable energy products
   Increase recycling diversion rates
C. Creates empowerment thereby curbing social ills

Challenges of Poor Performance of W. M. Agencies in Nigeria

The many problems of waste management agencies in developing countries are numerous but not limited to-poor funding, inadequate capacity building, obsolete equipment, endemic corruption, infrastructure deficit, near

absence of political will and weak enforcement of regulations amongst others. These inherent and systemic problems give birth to challenges such as unscientific approaches, improper collection of waste, and unethical practices, lack of data on waste and management processes, lack of qualified manpower, dearth of facilities, negligence of assigned duties, and the general inability of the agencies to deliver optimal services. The problems and challenges pops-up human and environmental consequences such as air and water pollution, unhygienic environment caused by inadequate collection of waste, ground water and surface water contamination from leachates from uncollected waste heaps, flooding caused by haphazard waste disposal into water channels, blocked drains from solid waste dumps, urban aesthetics compromised by heaps of refuse in urban fringes, health diseases from waste heaps and stagnant water that breads disease vectors, fires risks prompted by unregulated waste dumpsites and a host of others. Consequently, for Nigeria to overcome these problems, challenges and consequences that have become the identity of developing countries in terms of waste management, calls for the robust use of smart technologies. There is no doubt that waste management is a social, economic, and environmental problem facing developing countries, and if the UNDP 2030 Agenda for sustainable development is to be achieved the time to act is now (Godfrey, *et al*, 2019)

2.2 Theoretical Review

Crafting a theoretical framework for institutional waste management is an attempt to provide a unified body of knowledge about waste and a panacea for its effective management founded on the expectation that waste management is to prevent waste from causing harm to human health, the environment and also to promote resource use optimization. It is an effort to organize the diverse variables such as manpower, equipment, data on volume of waste, PSPs, etc. of the waste management system as applicable or as it stands today. In other words, waste management theoretical framework could also be done along the line of theories of waste management, theory of urban ecology, policy making, eco-innovation, triple-bottom, waste management and sustainability (Lagman-Baustista, 2019).

Management theory

As the father of modern management theory, Henri Fayol, a French Mining Engineer developed the 14 principles of management, published in his book-Industrial and General Administration in 1916 (Ward, 2021). Therefore, the Henri Fayol's principles of management are highly recommended for waste management because they are beneficial for prediction, planning, decision-making, organization and process management, control and coordination in the activities of the waste management which are applicable tools for smart technology waste management.

The theory of Urban Ecology

The goal of the urban ecology is to achieve a balance between human culture and the natural environment founded by Robert Park and Ernest Burgess in a distinctive program of Urban Research in University of Chicago in 1925 Brown, (2002). This theory preaches urban sustainability in respect of the relationship between economic, environment and social agents ensuring there is a balance between production and the natural environment in the area of generation and waste management.

Triple Bottom Line Theory

The Triple Bottom Line (TBL) Theory was developed by John Elkington in 1994. TBL is a sustainability theory which incorporates three dimension of performance, social, environment and finance restructured as the three Ps-people, planet and profit Vaidya, (2022). It seeks to gauge a corporate social responsibility and its impact on the environment. The lesson here for the research is that the corporate world should make allowance for environment management in their activities, leaning towards smart technology to minimize waste.

Industrial Ecology Theory

The industrial ecology theory, popularized in 1989 by a scientific American article published by Robert Frosch and Nicholas Gallopoulous on the assumption that industrial system should behave like an ecosystem where the waste of one activity can be the resource of another and the output of an industry be the input another (Frosch and

Gallopoulous, 1989). Thereby reducing the use of raw materials, reduction of pollution and minimizing waste treatment (which is all about cost effectiveness) the essence of smart technology.

2.3 Empirical Review

Muthoni (2018) conducted a study on IoT for African Smart Cities: A model for smart city solid waste management system in Nairobi. The data analysis was done with the aid of RapidMiner, Google suite and SPSS Statistic software. The results revealed that 68% of solid waste uncollected and 33% collected leaving a volume of 2690 tons daily uncollected, 71.7% projected as residential waste generation.

Also highlighted are weak regulations and poor compliance. Nabegu & Mustapha, (2015)," Institutional Constraints to Municipal Solid Waste Management in Kano Metropolis, Nigeria". The variables are decentralization of SWM system, PSPs, sustainable financial mechanism, stakeholders, regulations and enforcement. Design of study involves desk study of documents relating to the legal provisions and institutional arrangements for municipal waste management. Analysis done by proportion percentages and the findings indicate that 79.25% of the population do not use authorized dump site, 68% consider the service as very poor, for frequency of collection 55% say it is unsatisfactory. In Khan & Ali (2021) "Facilitating framework for a developing Country to adopt smart Waste Management in the context of Circular Economy (Pakistan). The variables are technologies and components of circular economy. Design of the study reflects determination of criteria from reviews and administration of questionnaire; data analysis done with application of Fuzzy SWARA. Findings reveal that 70% of imported energy can be avoided by looking inwards applying thermochemical processes. Also the study established that out of 13500 tons of waste (Karachi), only 60% collected and 40% uncollected with the rest left on the open ground highlighting Issues of poor regulations, weak political will, poor digital services and other supporting infrastructures. All the empirical reviews recommend the use of technology amongst others for cost effective waste management. The benefit developing countries have is that they have immediate access to robust tools today, and can begin to enjoy the benefits of smart technologies right away (Ross, 2017).

3. Methodology

For comprehensive data collection, the research adopted the use of interview questionnaire survey method involving the sample of 400 persons which were served with interview questionnaire and data was analyzed with various statistical instruments such as proportion percentages and presented using tables, bar and pie charts to deduce findings and recommendations. Primary data collected through the administration of household and institutional questionnaires and secondary data from relevant published and unpublished materials. The sampling method adopted to arrive at these L.G. A's choice is the purposive sampling technique.

The Slovin formula was used for the calculation of the sample size. The formula of Slovin can be written as-.

Determining of the sample size:

Slovin's Formula

$$N = \frac{\mathrm{N}}{1 + \mathrm{Ne}^2}$$

Where n= sample size
N=population size
e=margin of error

By substitution using the Slovin`s formula, the calculation can be seen as follows: -

N= 675,149

e= 0.05

Therefore, 675149/1+675149(0.05x0.05) =675150/1688.875=399.76, approx. =400

n=400. (Sample size). (Using percentages work out the number of questionnaires for each L.G.A Hqtrs for distribution accordingly)

By substitution using the Slovin`s formula, the sample size is 400 (5% of households in the affected study zones put at 8000).

Methods of Data Analysis

Data analysis is the process of analyzing data to extract insights that support decision making. There are several methods and techniques to perform data analysis depending on what is at stake or to be derived, which include statistical tools such as, multiple regression, standard deviation (residual), chi-square test, student-t-test-distribution tables for values (F- distribution tables) from R.A. Fisher statistical tables (using Excel-SPSS) analysis of variance (ANOVA), correlation analysis, etc. Amongst the array of these statistical tools, Analysis of Variance (ANOVA) in conjunction with F-distribution tables, are here adopted for the research. This method is deployed because of the homogeneity of the data collected and also for better deductions.

Data Presentation and Analysis

4.1 Results Presentation

The research covers the appraisal of the performance of waste management agencies in Nigeria and the implication of the use of smart technologies. For the purposes of data collection to anchor the appraisal, Delta State (Asaba, Ughelli and Warri) was selected for a pilot survey using purposive sampling technique and Slovin's sample size formula to deduce a sample size of 400 respondents, interviewed with structured household and institutional survey questionnaires, the result is here presented using various statistical instruments of data presentation, reflected as follows (Figures 4.1-.2.3) &table 4.0:-

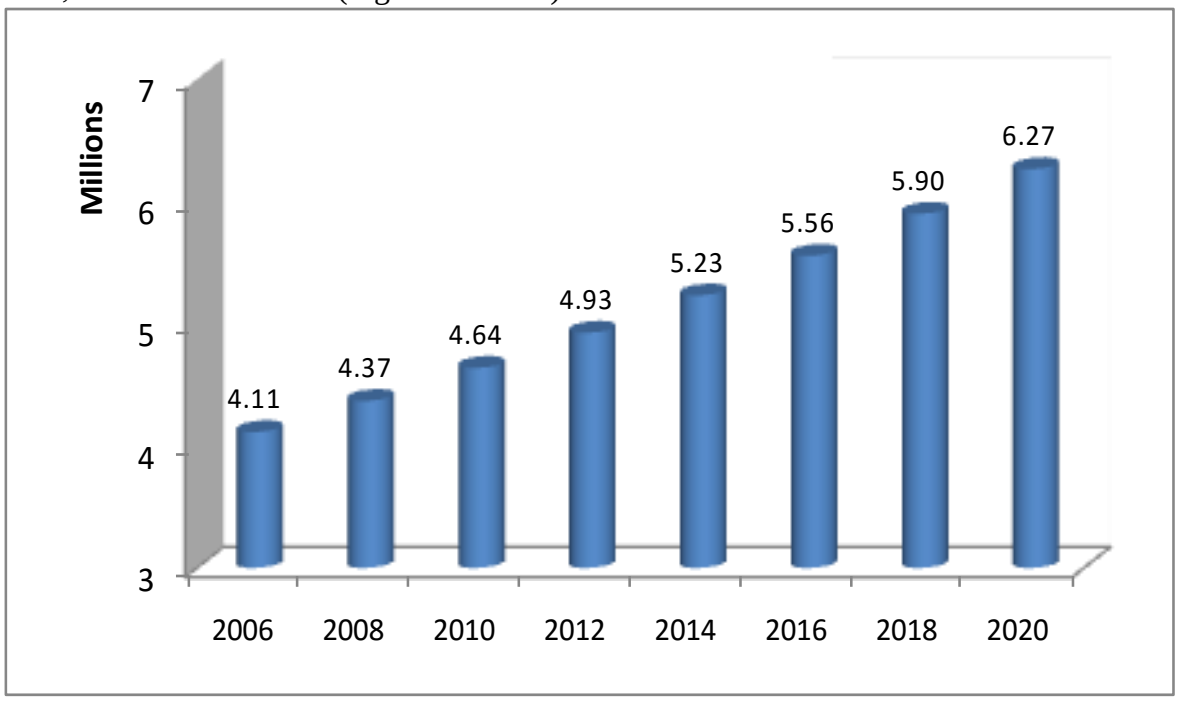

Figure 4.1: Population Projection for Delta State, Nigeria.

Source: NBS, 2006

The population distribution on Figure2 as published by the Nigeria Bureau of Statistics depicts a steady rise in population numbers also applicable to Nigeria and most developing countries and a resultant pressure on services that should be taken seriously by Policy makers and Planners especially in the area of waste management.

4.1.1 Employment Status

This study assumes that this variable significantly affects and influences both efficiency and the effectiveness of the capabilities of the institutional framework of solid waste management in Delta State to deliver optimal

services. Therefore, the result of this investigation (see table 4.7) show that 52.8 per cent of the sampled workers (38 out 72) considered low remuneration as the major problem of this job, while 15.3 per cent (11 out of 72) felt that workers were too few in the number for an effective performance of their tasks. This study assumes that this variable significantly affects and influences both efficiency and the effectiveness of the capabilities of the solid waste management Agencies in Nigeria to deliver optimal services.

Table 4.0: Employment Issues in Solid Waste Management

Problems in Delta State

Problems	**Number of Respondents**	**% of Sample of Workers**
Job too dirty	1	1.4
Job too hard	2	2.8
Wages too low	38	52.8
Too few worker	11	15.3
Over- "Bossy" Supervisors	14	19.4
Others	2	2.8
Total	72	100.0

Source: *Researcher's Field Survey, 2023.*

Furthermore, the result of the survey as illustrated by Table 4.0 also indicates that poor job performance in solid waste management can be partly explained by the inadequacy of work force with 15.3 per cent of the sampled workers (11 out of 72) gave this factor as one of the major constraints to effective solid waste disposal. These workers were further asked to provide as they considered fit, possible alternative to their job condition as characterized in these findings. The results show that 19.4percent (14 out of 72) plan to quit their job over 'Bossy Supervisors' if any other employment opportunity is available elsewhere, while 52.8 per cent (38 out of 72) prefer to meet the management for improvement in the conditions of service (better pay, and generous over-time bonus payments. The implication of this analysis is that, there is low motivation of workers due to poor wages and inadequate staffing which has hampered Agencies ability to carry out their assigned duties effectively

4.1.2 Job Satisfaction

On the question of job satisfaction, the response of sampled workers (see figure: 4.2) shows that 31 of the 72 sampled workers representing 43.0 per cent found their job unsatisfactory. The results also reflect that a further 15 out of 72 representing 20.8 per cent were just managing, while 10 out of 72 representing 13.9 per cent plan to resign. Furthermore, 9 respondents out of 72 representing 12.5 per cent perceived their work as having no future. It is not surprising that only 4 workers out of a total of 72 sampled or 56 per cent rated their job as satisfactory. The Capacity building and the use of state-of-the-art equipment could help in a long way to encourage workers' stay on their job.

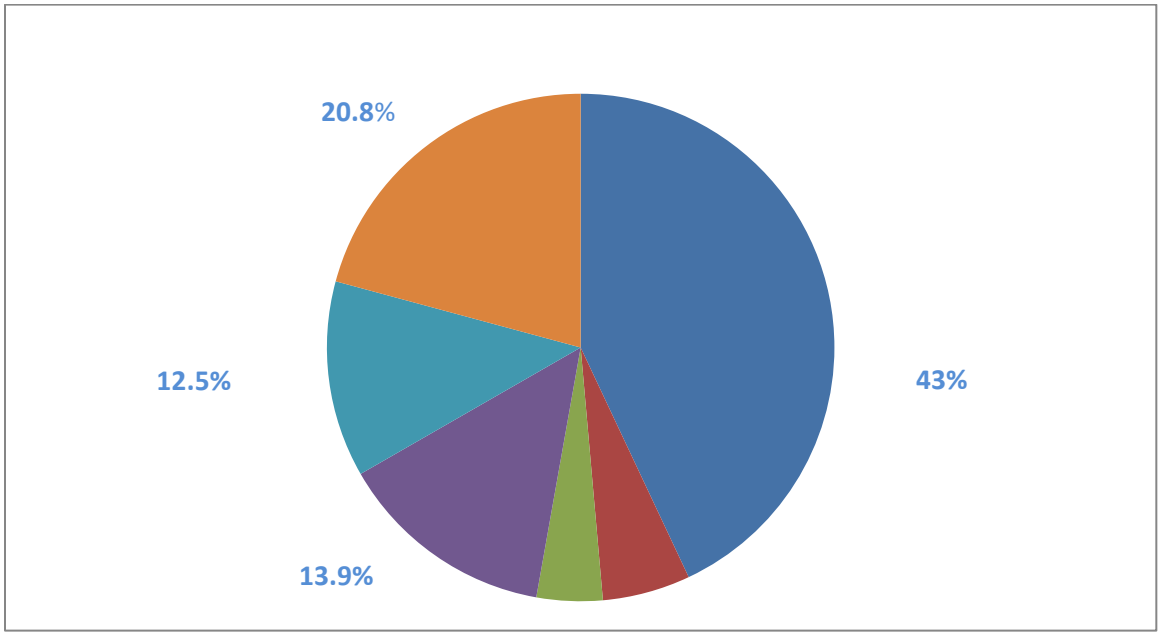

Figure 4.2: Job Satisfaction, Source: Researcher's Field Survey, 2022

4.1.3 Typology of Solid Waste

Figure 4.3 reflects the typology of the solid waste constituents' mostly constituting eyes sore in the urban environment of Asaba, Ughelli and Warri as revealed by the survey responses. The table shows that 65.25% present of sample households (261 out 400) have food remnants as the greatest volume of their domestic solid waste.

The type of waste and its volume mostly disposed haphazardly by residents has negative implications for environmental sanitation, at least under an ineffective agency heralded by poorly organized disposal system.

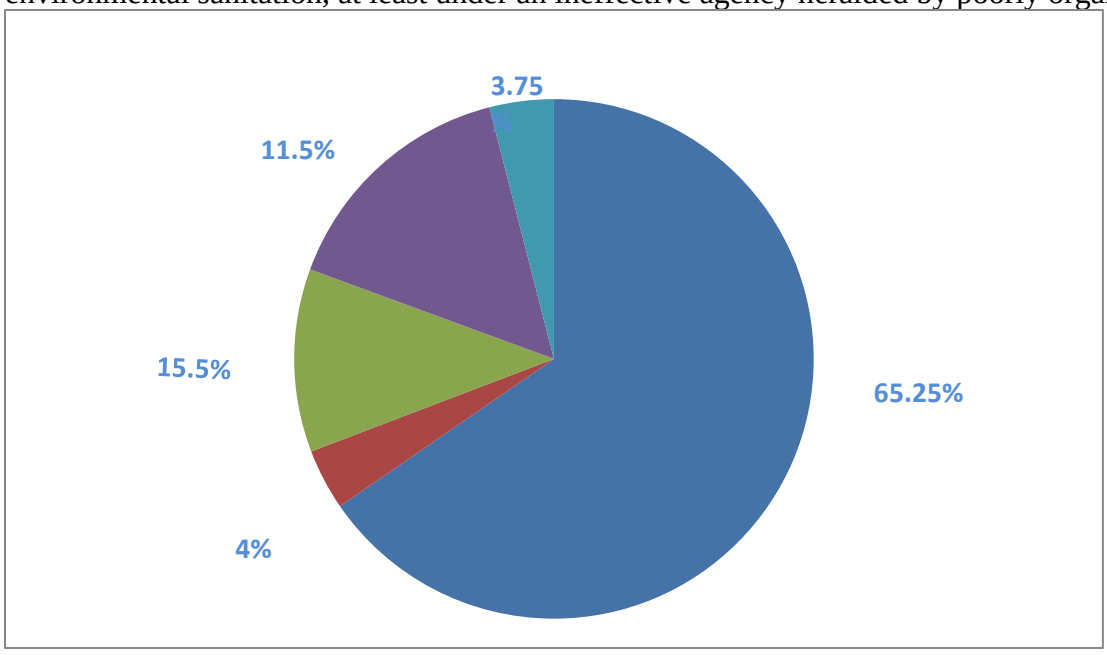

Figure 4.3: *Types of solid Waste*
Source: Researcher's Field Survey, 2022

4.1.4 Nature of Nuisance caused by uncollected Solid Waste

During the field survey, an attempt was made with the use of questionnaire to reveal specifically the nature of the environmental nuisance in the residential areas through responses from the residential population in the area. The responses are illustrated in Table 4.1.

Table 4.1: Nature of Nuisance Caused by Uncollected Solid Waste in Nigeria (Delta State)

Nature of Nuisance	Response Frequency	% of Sample Household
Smell	85	2i.25
Irregular Clearing	110	27.5
Dumping Directly on Ground	67	16.75
Flies, Mosquitoes	115	28.75
Others	23	5.75
Total	400	100.00

Source: Researcher's Field Survey, 2022

It is hereby observed that, 28.75 percent of the sample respondent households consider problems of houseflies, mosquitoes and rat infestation as the greatest environmental pollution evidence resulting from open dump, and heaps usually developed over time from accumulated dumping of waste.

4.1.5 Methods of Solid Waste Disposal

Table 4.2, represents approximately the sampled three LGAs Headquarters in Delta State and the daily collection of urban solid waste and its disposal points as in most areas in Nigeria. The various locations where it is dumped include open dumpsites, open drains, open spaces and street intersections. Environmental impacts of these practices in each of these sites vary considerably. For example, where refuse is dumped in open storm water drains, it creates a barrier to storm water flow. This results in erosion and flooding caused by solid waste blockades. This is a common phenomenon along major roads and street intersections in Delta State, Nigeria. In open spaces, refuse is generally piled growing into a mountain over time, blocking pedestrian and vehicular traffic and causing traffic congestion.

Table 4.2: Methods Solid Waste Disposal in Nigeria (Delta State)

Method	Response Frequency	% of Sample Household
Dump in gutters & Streams	42	10.5
Deposit in open Space or Street	231	57.75
Use Depots	0	0.0
Use Dustbin	102	25.5
Others	25	6.25
Total	400	100

Source: Researcher's Field Survey, 2022

Due to lack of compacting or control of open dumps, too many sites have been used as open dumps simply on the basis of their availability and access, with no attention paid to problem of leaching of waste water resulting in surface water contamination and environmental pollution.

In this study, 57.75 percent of the sampled household (231 out of 400) utilize open spaces within residential neighborhood, or directly into nearly open storm water drains for dumping solid waste. As is evident from table 4.2 none of the sampled household patronized prescribed public solid waste dumpsites.

4.2 Data Analysis

The Analysis of Variance (ANOVA)

Amongst all the groups implied in the sample, the Analysis of **Variance** (ANOVA) as created by a notable analyst Ronald Fisher has been utilized strongly in statistical hypothesis speculation testing for ages in that its output provides an estimate of how much variation in the dependent variable that can be explained by the independent variable. For examining the experimentation of information analysis, **ANOVA** assumes a better significance. In the ANOVA test, we use Null Hypothesis (Ho) and the Alternative (Ha). For instance, the Alternative Hypothesis is valid, when at least one of the variables stands differently from the others, which is the situation with the variables in the research (Sullivan, 2019). The PSPs as independent variable stands alone because it is privately driven unlike the dependent variables such as funding, equipment, manpower, etc. that are propelled by institutional governance structure.

Discussion of Findings

Although smart waste management is the way to go in Nigeria, however the use of smart technologies will slightly improve the performance of waste management agencies because of their inherent and systemic challenges which include poor budgetary allocations culminating in poor funding, inadequate investment in ICT and other supporting infrastructures due to lack of political will, endemic corruption and poverty. This is the situation in most developing countries like Nigeria, India, Mexico, Sri Lanka, Thailand, Ghana, etc. Some of these countries are still saddle with the medieval methods of open trucks and donkeys transporting solid waste to dumpsites with half of the load spilling on the streets. In Nigeria trucks carrying effluents still queue up to empty their waste into rivers, lakes, oceans/sea untreated causing harm to aquatic species and riparian communities. In India, the Urban Local Bodies (ULBs) are held hostage by government bureaucracy, poor funding and lack of human and material capacity to deliver on effective services. Smart technologies will improve the performance of SWM agencies in developing countries.

Consequently, it is an incontrovertible fact that smart technologies will improve the performance of waste management agencies in Nigeria with the highly demonstrated success story of Singapore amongst others in touting the benefits of smart waste management. For instance, Singapore has been able to change the narrative by thinking outside the box deploying the use of technologies in waste management. There is no doubt, smart technologies offer better management options that are cost effective and efficient placed side-by-side with the inadequate institutional budgetary allocations for waste management in developing countries. This is the direction Nigeria should be heading if Nigeria is to be part of the UNDP's development agenda for 2030.

5.1 Summary of Findings

Proper waste management is not only beneficial to a viable environment but also has serious economic and environmental benefits. The empirical reviews reveal how 68% of waste is left uncollected in some human environments and also the analyzed data reflects how about 51% of citizens' dispose-off waste in community dedicated dumpsites with serious environmental implications. An occupancy ratio of 6-8 persons adding up to 33.3% for persons living in a room has serious management implications for proper waste management. The research props-up some other concerns as follows: -

i Poor education and enlightenment on environmental habits and how to imbibe hygienic environmental practices traceable to weak institutions and near absence of the needed political will to galvanize proper institutional waste management;

ii Obsolete equipment and facilities that have become outdated with complex management and maintenance difficulties, due to poor budgetary allocations that have created inadequate funding for proper waste management activities in most developing countries; and

iii Lack of the necessary ecosystem to encourage citizen participation especially those that generate and dispose waste in developing communities due to endemic corruption that has stifled the growth of technological transfer and leadership issues common in developing countries.

5.2 Conclusion

The World Bank in 2000 committed $4.7 billion in more than 340 solid waste management programs in 6 regions of the world concerning World Bank engagements, most of those affected are in developing countries such as Morocco, $500m, Argentina, $40m, Indonesia, $100m, Burkina Faso, $ 67m, etc. The waste management system in a developing country like India is in a critical state, as ULBs have largely failed to manage solid waste efficiently. Being heavily dependent on governments for funding, these local bodies lack the resources to acquire more land for dumpsites or obtain the necessary technologies required for efficient SWM. Agencies in reality should become smarter and more efficient with the mountains of refuse compromising the human landscape in developing countries. The age of analog and rudimentary approaches is gone, we are in the age of ICT and IoT involving the use of sensor bins with self-sorting devices, garbage bullock trucks that can compact and compress waste with inbuilt devices such as wood grinders and can crushers, enlarging the volume capacity of the truck to 8 times its normal capacity. Developing countries should not be left out in this waste revolution. With proper investment in the relevant waste management agencies, they could deploy smart technologies for better performance to achieve sustainable environmental quality by turning waste to energy, waste to employment and waste to wealth (Appendix III) in developing countries using smart technologies in the waste management value chain.

5.3 Recommendations

The Findings reveals a lot of thought-provoking situations in the waste management spectrum in Nigeria that needs to be addressed through the following recommendations that are not exhaustive.

i. Collection and disposal of waste should be automated deploying the use of smart technologies, involving sensor bins and bullock compactor trucks with vacuum suction system has become necessary to address the issue of efficiency- creating smart waste collection. There should be serious concerted government efforts at ICT development and provision of supportive infrastructural facilities which are at their lowest ebb of development in developing economies;

ii. There should be improved budgetary funding for the relevant Agencies of waste management to enable them acquire up-to-date tools for modern smart waste management. The waste management agencies should be autonomous, removed from the bureaucracies of governments. This will help them to expand their activities and enhance creativity; and

iii. There is the need for agencies to build a data bank on waste and waste management for digitilization of operations and sustainable management practices. The agencies are devoid of data on the amount of waste generated and disposed.

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