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Household Waste Management Logistics Practice in Lagos Metropolis, Nigeria

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Abstract. Waste management is a major problem plaguing most cities in developing economies, including Nigeria. The issues of waste management, particularly in Lagos, Nigeria, are not unconnected to the unprecedented population increase with a poor integrative process of handling and transporting waste from points of generation to disposal, which in turn affects the healthiness of residents and the sustainability of the built environment at large. Based on this backdrop, this paper examined the household waste management logistics practice in the Lagos Metropolis. The primary data used consists of a questionnaire distributed to residents, supplemented by structured interviews with PSP operators and personal field observations. Systematic-random sampling was used to administer 694 units of the questionnaire. Findings revealed that organic (food) waste, which is mostly stored in drums, accounted for most of the generated household waste. It also revealed that transport distance and environmental attributes are the most important factors affecting the performance of waste collectors in waste management logistics. This study further revealed that PSP operational performance is far from being efficient as the volume of waste evacuated is low and the turnaround time of fleets is extremely high. Our study also revealed that transportation plays the most significant role in waste management logistics. Our study, however, recommends, among others, that the operations of waste management should not be limited to PSP operators but also involve the local government authorities, while improved quality of transport options and route optimization are recommended mechanisms for mitigating logistics weaknesses in waste management practices.

Keywords: Waste management, logistics, transport, private sector participation PSP and Lagos Metropolis.

1. Introduction

Waste management is a major problem plaguing most cities in developing economies, including Nigeria. Obviously, waste management issues, particularly in Lagos, Nigeria, are fast-increasing and the reason is not unconnected to the quagmires of waste logistics practices vis-a-vis poor integrative process of handling and transportation of waste materials from points of generation through inappropriate and unstandardized vehicles to the approved disposal landfills and/or the treatment and recycling plants, which in turn affects the healthiness of residents and the sustainability of the built environment at large. Waste management has always been a major challenge faced by urban dwellers around the world, most especially in developing nations (Abdel-Shafy & Monsour, 2018; Ayantoyinbo & Adepoju, 2018; Agarwal, Chaudhary & Singh, 2015; Miezah, Obiri-Danso, Kadar, Fei-Baffoe & Moses, 2015). Improper waste management and its defective logistics mechanism have become one of the major concerns globally, posing great danger to public health and the well-being of residents and visitors in the built environment.

The unprecedented growth of the population, rapid urbanization, a booming economy, an improved standard of living, and the influx of people to cities and other prosperous urban centres for greener pastures have always been contributory to an increase

in waste generation with attendant consequences in the cities (Yoada, Chirawurah, & Adongo, 2014; Abdel-Shafy & Monsour 2018). Also, it is not an overstatement that the economic and oil boom of the 1970s in Nigeria has led to the rapid growth of urban centres, an increase in standard of living, industrialization, and the migration of people from rural areas to cities, which has ultimately increased waste generation in the country. However, the need to take precautionary measures against health hazards and other environmental degradation associated with poor waste management processes, such as improper waste generation, collection, transportation, and disposal, highlights the need for holistic measures, particularly in fast-growing cities such as Lagos, Nigeria.

Regrettably, poor transportation and logistics systems as well as weak waste management mechanisms, especially in Lagos and other cities in the country, have been contributing to urban decay and the possible outbreak of communicable diseases (Fasina, Salisu & Akanmu, 2020; Adeosun, 2018). Worthwhile, the most salient issue in waste management remains the poor modus operandi of waste collection, handling, transportation, and disposal, which is also known as the waste logistics issue. Waste logistics is an integrative process that seeks to optimize the management of the flow of waste materials such as organic waste, plastic waste, waste paper, tin cans, electrical electronic waste, composite waste, hazardous waste, medical waste, and aluminum waste through single and multiple vehicles, collecting many different waste material types from the generating or supplier's point for drop off (Fasina et al., 2020). It also includes adequate handling at a range of waste management facilities such as dumpsites and landfills within urban and rural locations, ensuring the development and configuration of upstream and downstream waste transfer, treatment, and disposal mechanisms (Sanni, 2016).

Basically, improper and inaccurate understanding of factors of waste logistics vis-à-vis waste generation, information, sorting, collection, handling, inventory, transportation, disposal, and re-use ultimately impacted the overall waste management logistics, a situation attributed to inaccurate or failed logistics processes in waste management in the built environment. Generally, Afangideh (2012) states that problems associated with waste management logistics are greatly felt in all facets of the society of developing and developed cities. Such problems range from different components of municipal waste management logistics and they include but are not limited to lack of waste generation information, poor collection and storage facilities, deplorable transportation situation, inadequate and unsuitable transport facilities, poor route optimization, poor locational state and distribution pattern of disposal landfills, poor customer service and information, lack of inventory control mechanisms, poor waste marketing, and poor re-use or recycle mechanisms, which in turn can be summed up in one word, "waste logistics weakness".

Failure to understand and address waste logistics issues logically means that Nigerian cities will become increasingly polluted and unhealthy, as well as less functional and unsustainable. Consequently, Lagos, the most populous state and one of the fastest growing cities in the world, aside from being the commercial and industrial nerve of Nigeria (Oyesiku, 2017), has a huge burden of waste management infractions occasioned by defective logistics processes considering the fact that waste generation in the city is about 70%, while its disposal rate is just 30% (Edu, 2003; Ayantoyinbo & Adepoju, 2018). More so, the city lacks information on the inventory of waste generated and disposed of in all the government-approved landfills. This study is interested in how best logistics practices can be integrated into waste management in order to improve waste logistics quagmires in Lagos, Nigeria. Based on these considerations, this study evaluated household waste management logistics practice in Lagos Metropolis, Nigeria, with the overall goal of achieving and providing better waste logistics mechanisms to improve waste management, healthy living, and the built environment. In achieving this aim, specific objectives pursued were to examine the socio-economic characteristics of households representative in Lagos Metropolis; assess the nature and characteristics of household waste management in Lagos Metropolis; assess the performance of waste collectors in waste management logistics in Lagos Metropolis; examine the factors affecting the performance of waste collectors in waste management logistics in the study area; examine the logistics of waste generated and disposed in the study area; analyze the factors that determine the best practice of waste logistics in Lagos; identify the challenges faced by PSP operators in waste management in Lagos; and finally, Nigeria towards ameliorating the logistics weaknesses in waste management.

2. Literature Review and Conceptual Clarification

2.1 Literature Review

As the movement of goods and services is very germane to the economic development or growth of a nation, so also is the evacuation of unwanted or waste material from our surroundings. Waste is presumed to be any material flow that is rejected by society that needs to be safely evacuated and also remains an inevitable product or byproduct of human activities in space that poses any danger to humans and the environment (Adewunmi, Ogedengbe, Adepetu & Aina, 2005). Before waste can be transported from collection points to disposal sites, there must be efficient transportation and logistics means to use and with which physical distribution of garbage would comply. Undoubtedly, transportation and logistics are key factors in the waste management system.

Janusz and Mariana (2014) defined waste management logistics as the creation of a logistics chain to convey waste from point of collection to treatment or disposal point, while solid waste management is defined as things that connote waste generation, storage, collection, and transfer, transportation, processing, and disposal of waste in accordance with public health, engineering conservation, aesthetics, and other environmental considerations (Aribisala & Ikudayisi, 2012). Achi, Adeofun, Ufoegbune, Gbadebo, and Oyedepo (2012), identified problems associated with waste management logistics as the inability to determine an appropriate route to take, inadequate operational vehicles, and the location and allocation of sanitary landfills, which are inappropriate. It can be seen that transport functionality is very key, important and the most powerful tool in waste management.

Meanwhile, Aribisala and Ikudayisi (2012) observed that when solid waste, particularly organic solid waste (food waste), is wet or soaked with water, it takes more space and weight in transportation vehicles, resulting in more energy cost in fuel consumption and fleet costs. It is equally difficult to measure. Ayantoyinbo and Adepoju (2018) asserted the fact that for sustainable waste management to be achieved, transportation and logistics play a vital role, and further suggested two possible strategies for waste management logistics: either to allow waste to reach a sizeable volume before evacuation or to provide a rapid transport system for its removal. Ogra (2003) observed that through the help of Geographical Information Systems, one can be able to determine transport routes for efficient waste collection to reduce cost and increase efficiency. The use of technology is inevitable in waste collection logistics.

Also, Sinare (2017) noted that inadequate vehicles and unsynchronized transport systems to the system of waste primary collection and bulky waste storage facilities in Ambajogai city are a great bottleneck to efficient and sustainable transportation of refuse. It was also observed that operating vehicles were not covered with tarpaulin to prevent being blown off in the wind while on transit. Stojanovic and Knezevic (2017) explore in depth the importance of transport and the involvement of the informal sector in waste management. It was discovered that inefficient waste management logistics would give rise to high costs of waste management and inefficiency, hence the introduction and issuance of licenses by the government to private waste logistics providers to ameliorate the problems and inefficiency in that sector. Municipal waste collection and management connotes high operational costs in fleet management and the cost to the environment through the emission of obnoxious gases, noise pollution, and traffic (Faccio, Persona & Zanin, 2011).

It is worthy to note that, from the literature reviewed, there is a paucity of studies on the importance of waste logistics in the overall waste management mechanism and sustainable built environment in fast-growing cities. Based on this context, this chapter addressed logistics component issues such as the nature of waste collection and disposal; type of waste storage; frequency of waste collection (trip making); trip duration and trip distance by waste vehicle operators; number of fleet required to keep up with ever increasing waste generation; inventory of waste generated; and the effect of waste logistics and landfill locational impact on the built environment of Lagos Metropolis.

2.2 Conceptual Clarification

2.2.1 Concept of Logistics

Physical distribution as part of management science emerged in the early 1920's when it was realized that production efficiency through effective transportation and distribution processes, which had been the basis for competitive advantages among manufacturers, was taken over by the standardization of many fabrication processes that in-turn affected demand and supply chains globally (Benson, Bugg, & Whitehead, 1994). Logistics originated from the French word logistique, which means accommodation. According to EuPortal (2003),

logistics was originally used in the military to manage the flow of personnel and materials support for fighting troops, such as transportation, food, medical services, repair services, and so on.
Logistics is part of the supply chain process that plans, implements, and controls the efficient and effective forward and reverse flow (waste) and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements. Logistics is, however, described as the entire process of materials and products moving into, through, and out of a firm or city. That is, it is a form of material management that describes the movement of materials and components effectively and efficiently at the right time, to the right place, and for the right person in the right manner. Inbound and outbound logistics are of two types. Inbound logistics covers the movement of material received from the start to the end of an assembly line of suppliers, while outbound logistics refers to the movement of goods outward from the end of the assembly line to the customer. Finally, supply-chain management is somewhat larger than logistics, and it links logistics more directly with the users' total communications network and with the firms' or cities' engineering (Benson et al. (1994).

Also, logistics is seen as the process of moving and handling goods and materials from the beginning to the end of the production, sale, and waste disposal processes to satisfy customers and add business competitiveness (Sanni, 2016). Somuyiwa and Oyesiku (2010) note that at every step in the logistics practice in any organization or city, there are costs involved resulting from the factors that determine logistics practice. However, the major cost drivers in logistics are transportation, inventory control and management, warehousing and storage, information flow technology and order processing, packaging and material handling, as well as customer service (Fig. 1).

Logistics, however, is the art of maintaining control over a worldwide supply chain by a combination of transportation, warehousing skills, distribution management, packaging, information technology, inventory management, and customer service as illustrated in Figure 1. Transportation, as one of the components of logistics, bridges the geographical gap and spatial dichotomies in the complex pattern of manufacturing centres, sources of raw material supplies, depot locations, and marketing outlets that are such ubiquitous features of the modern multinational company. Warehousing keeps goods of every sort, including municipal waste, from raw materials or source point to finished product for use point and also secures them in the gaps that separate production from consumption. Distribution centres accept and hold buffer stock until required and then route them to the factories, wholesalers, and retailers that require them.

Information technology keeps track of where everything is alert, those who need to be informed of amended instructions, documents, stock, orders, transit, arrivals, and departures. Inventory management oversees the control of ordering, storage, and use of components used in production as well as the control of the quantity of finished products for sale (Sanni, 2016). Packaging focuses on the technology of enclosing or protecting products for distribution, storage, sale, and use. Customers' information and services, which are the life blood of a modern organization, keep and control the transmission of information the stakeholders abound.

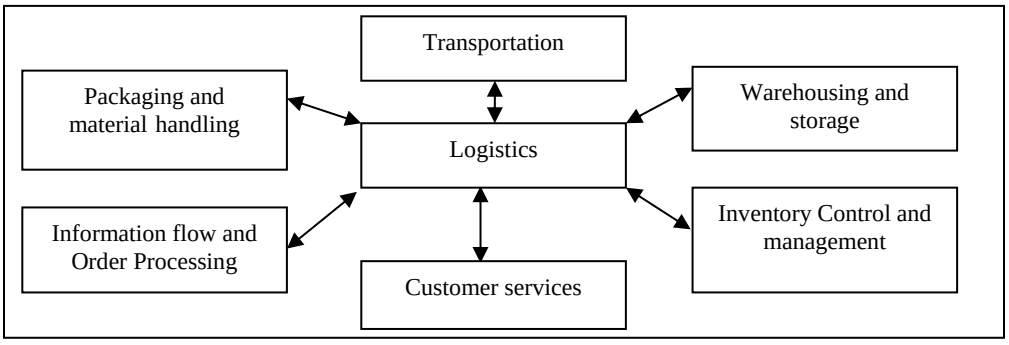

Figure 1: Component of Logistics System
Source: Adopted from Benson et al. (1994), pp. 159

3. Research Methodology

3.1 Study Area

Lagos is located at longitude 20º42ºE and 32^{0}2ºE and latitude 60º22ºN and 60º2ºN. It is bounded to the north and east by Ogun State, to the west by Benin Republic, and to the south by the Atlantic Ocean. The state covers an area of 358862 hectares, which represents 0.4% of Nigeria's territory (George, 2015). The state has two climatic seasons: wet (April-October) and dry (November-March), with swamp forest and mangrove swamp dominating. Lagos is a small city in Nigeria because of its landmass but with the highest urban population, which is 27.4% of the nation's estimated total, with twenty (20) Local Government Areas and a population of 9,013,534 (National Population Census, 2006).

3.2 Methods of Data Collection

The data sources for this research were obtained through primary and secondary data sources. Primary data was collected majorly through the use of a questionnaire administered to the household representative, complemented with an interview-guide administered to a private sector participation (PSP) representative in Lagos, Nigeria, as well as direct field observations conducted by the authors. The questionnaire administered to the household representative sought data on the socio-economic characteristics of the household, the nature and characteristics of waste management, the performance of waste collectors in waste management logistics practice, factors affecting the performance of waste collectors in waste management logistics, the logistics of waste generated and disposal methods, and the factors that determine the best practices of waste logistics in Lagos, Nigeria. However, the questions were close-ended in design and were mostly on a Likert scale of four-point response rating. The interview-guide administered to the representative of PSP sought information on the involvement of private sector participation (PSP) in waste logistics, the factors that determine the best practices of waste logistics, as well as the challenges faced in the logistics operation of waste management in the study area. Meanwhile, the researchers also observed the operation of waste disposal directly along and within sampled landfills or dumpsites during a field survey exercise conducted. In other words, the secondary data was gathered from both published and unpublished materials on related topics that were relevant to building both a literature review and conceptual clarification for the study.

Based on the information received from Lagos State Waste Management (LAWMA), there are three (3) government-approved sanitary landfills and two (2) temporary sites for municipal waste management in Lagos State. Two (2) out of the three (3) approved landfills, namely Olushosun in Ikeja Local Government Area LGA and Solous 3 in Ojo LGA, were randomly selected for this study. Consequently, these two are the most popular in terms of use and design capacity. This study is delimited to the radius of two Local Government Areas (Ikeja and Ojo) where the two landfills are sited in Lagos State as the focus areas for this study. Hence, the total number of buildings in the two selected LGAs in Lagos State serves as the population of the study area. The number of buildings in Ikeja Local Government Area according to the Lagos Bureau of Statistics (LBS, 2020) was put at 3,929 buildings with a population of 808,387 people, while Ojo Local Government Area, which hosts Solous 3 Landfill, has 2,767 buildings with a population of 963,215 people. This observed variation is not unconnected to the spatial features of the two selected LGAs.

The sampling size for this research work was drawn from the number of buildings in the study area of 3,929 in Ikeja and 2,767 in Ojo LGAs. A sample size formula was used to draw a sample from the study population. Taro Yamane's sample size formula is as follows:

$n=N/1+N*(e)^2$

Where n= the sample size, N= the population size and e= the acceptable sampling error.

A sample size of 694 buildings in the study area, accounting for 364 and 350 buildings in Ikeja and Ojo LGAs, respectively, was sampled. However, 694 copies of the questionnaire were administered to the household head or representative in the study area, out of which 678 (364 [Ikeja] and 314 [Ojo] copies, equivalent to a 98% response rate, were well completed, retrieved from the field survey and equally used for analysis. In other words, systematic-random sampling was adopted in sampling household representatives as respondents from the study population pool without bias. Through these sampling techniques, one (1) out of every five (5) buildings in the selected areas was picked for questionnaire administration. It is done by sampling every fourth (4^{th}) household representative systematically after the first is selected at random. The collected data was analyzed using both descriptive statistics. Descriptively, the data was presented in frequency percentage tables and charts, complemented with plates and figures to facilitate the

interpretation of collected data. However, the statistical package for social sciences (SPSS) version 21 was used in running the analysis.

4. Results and Discussion

4.1 Socio-Economic Characteristics of Residents

Out of 694 questionnaires administered, only 678 (Ikeja Local Government Area (Olusosun Landfill), 364 respondents, and Ojo Local Government Area (Soluos 3 Labdfill), 314 respondents) were duly filled and returned, making up 98% of the total questionnaire administered. It was observed that the majority of respondents sampled in both Ikeja LGA (female 57% and male 43%) and Ojo LGA (female 68% and male 32%) were female. The result shows that we have women as housekeepers while the males have gone out for their daily bread. Furthermore, it was observed that in Ikeja LGA, 76% of respondents sampled were between the ages of 46–65 years, while the majority in Ojo LGA were between 66–75 years.

The education attainment of the respondents revealed that the majority were educated, which accounted for 47% in Ikeja LGA and 54% in Ojo LGA. One can deduce that most of the respondents are conscious of things around them because of their educational attainment, and the management of household waste will not be a mirage to them. Furthermore, public workers account for 72% and 39% of those who are gainfully employed in Ikeja LGA and Ojo LGA, respectively, with private businesses accounting for 18% in Ikeja and 19% in Ojo, retirees accounting for 7% in Ikeja and 36% in Ojo, and the unemployed accounting for 3% in Ikeja and 6% in Ojo. Considering monthly income, the majority of respondents (59.2%) earn a monthly income of ₦25,001 to ₦125, 000 in Ikeja and Ojo. This result shows that the household has the tendency, propensity, and potential to generate more waste at present and in the near future, with attendant consequences. There is a need for the best possible framework and strategies for waste management logistics to meet up with ever increasing population growth and an increasing waste generation rate (Table 1).

Table 1: Socio–Economic Characteristics of Respondents

Variables	**Ikeja LGA**		**Ojo LGA**		**Grand Total**	
Sex	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Male	157	43	100	32	257	41
Female	207	57	214	68	421	59
Total	364	100	314	100	678	100
Age						
25 – 45	22	6	53	17	75	11
46 – 65	277	76	63	20	340	50
66 – 75	65	18	198	63	263	39
Total	364	100	314	100	678	100
Educational Status						
Tertiary	171	47	170	54	341	50
Secondary	127	35	104	33	231	34
Primary	04	01	25	08	29	05
Informal	62	17	15	05	77	11
Total	364	100	314	100	678	100
Employment Status						
Public	262	72	123	39	385	47
Private	66	18	60	19	126	27
Retired	25	07	113	36	138	20
Unemployed	11	03	18	06	29	06
Total	364	100	314	100	678	100
Monthly Status						
Below ₦25,000	11	03	25	08	36	05
₦25,001- ₦45,000	84	23	103	33	187	28
₦45,001-₦65,000	127	35	72	23	199	30
₦65,001-₦85,000	87	24	79	25	166	24
₦85,001-₦105,000	26	07	22	07	48	07
Total	364	100	314	100	678	100

Source: Authors Field Survey, 2020

4.2 Nature and Characteristics of Household Waste Management Logistics

Studying logistics practices of waste management in a city requires total understanding of the nature and characteristics of waste management vis-à-vis the type of waste, method of household waste storage, household waste collection means, and method of household waste disposal and means of waste disposal. It is worth noting that Table 2 revealed the

findings related to the nature and characteristics of household waste management in the study area. Findings revealed that food waste is the most generated waste in Ikeja LGA (58%) and Ojo LGA (54%), closely followed by plastic waste in Ikeja (31%) and Ojo (32%). Liquid waste related-waste generated usually from kitchen and laundry as well as electronic waste are of minimal percentage. The use of drums in waste collection and storage ranked 1st in Ikeja LGA (40%) and in Ojo LGA (54%). Storage through polythene bags with 34% ranked 2nd in Ikeja LGA and in Ojo with 28%. The observed variance in waste collection methods may be attributed to the cultural practice and the choice of the residents.

Methods of waste disposal are majorly through Private Sector Participation (PSP) Operators (Ikeja LGA, 65% and Ojo LGA, 48%). Cart pushers accounted for the least methods of waste disposal in the study areas (Ikeja LGA, 9% and Ojo LGA, 15%). While personal methods, that is, households that dispose of their daily generated waste personally without involving PSP operators or cart pushers, The personal methods accounted for a significant percentage and scored second place both in Ikeja (26%) and Ojo (37%) LGAs (Table 2). In other words, further investigation conducted on the personal methods of waste disposal of the residents shows that respondents who engaged in this practice mostly disposed of their waste directly to the dumpsite (73% in Ikeja and 82% in Ojo LGAs). This method of waste disposal can be adjudged as the most commonly used or traditional method of waste disposal in developing countries in Africa and Nigeria. Burning of waste through incineration takes the second place of the personal waste disposal methods engaged by respondents (Ikeja LGA, 22% and Ojo LGA, 13%).

Out of the total daily waste generated, the range-volume between 121kg and 160kg accounted for the most generated waste in Ikeja LGA, while a range-volume between 80kg and 120kg ranked the highest in Ojo LGA (Table 2). Meanwhile, the range-volume of less than 80 kg scored the least percentage of waste generated both in Ikeja LGA (07%) and Ojo LGA (07%). Furthermore, the household waste disposed by PSP operators is majorly transported through the use of compactors, accounting for 47% in Ikeja LGA and 66% in Ojo LGA. This is closely followed by covered trucks (30%) in Ikeja LGA and (22%) in Ojo LGA. The high usage and adoption of the compactors in the study area can be attributed to the safe and compact nature of the vehicle when on transit. The garbage is not blown off by wind, and the offensive odour of the garbage is confined within the compactor.

Table 2: Nature and Characteristics of Household Waste Management Logistics

Waste Management Indicators	**Variables**	**Ikeja LGA**		**Ojo LGA**	
		Freq	%	Freq	%
Type of Waste	Plastic	113	31	100	32
	Food	211	58	170	54
	Electronics	11	03	22	07
	Liquid	29	08	22	07
	Total	364	100	314	100
Methods of Household Waste Collection/Storage	Polythene Bags	124	34	88	28
	Drums	146	40	170	54
	Sacks	29	08	44	14
	Dust Bin	65	18	12	04
	Total	364	100	314	100
Volume of Daily Waste Generated	<80kg	26	07	22	07
	81-120kg	04	01	111	35
	121-160kg	295	81	107	34
	>160kg	39	11	74	24
	Total	364	100	314	100
Waste Disposal Means	Cart Pushers	32	09	47	15
	PSP Operators	237	65	151	48
	Personal methods	95	26	116	37
	Total	364	100	314	100
Personal Methods of Waste Disposal	Dumpsites	70	73	95	82
	Incineration	20	22	15	13
	Composting	5	05	6	05
	Total	95	100	116	100
Vehicle Used to Transport Waste by PSP Operators	Compactor	171	47	207	66
	Covered Trucks	109	30	69	22
	Articulated Van	47	13	22	07
	Open Truck	37	10	16	05
	Total	364	100	314	100

Authors Field Survey, 2020.

4.3 Performance of Waste Collectors (PSP Operators) in Waste Management Logistics

The performance of the PSP operators, who are the government-approved public waste collectors, was assessed by the residents in Table 3. Findings revealed that the majority of the respondents, 68% in Ikeja and 79% in Ojo LGA, assert that PSP operators only collect waste just once a week, while 26% and 12% in Ikeja LGA and Ojo LGA, respectively, are of the opinion that the PSP operators only show up twice a week. From the results, it is clear that the waste collection pick-up time by the operators is very poor, as the observed delay in waste collection leads to unwanted littering of the environment with garbage and other types of waste. In other words, in the quest to investigate from them the cause of the delay in pick-up time, they attributed it to waste collection payment as PSP Operators timely collect the household waste of those who regularly pay the monthly fee (over 70%) both in Ikeja and Ojo LGAs (Table 3). We can deduce that PSP operators are only concerned about their payment rather than the collection of waste generated. Invariably, this contributes to why there is always a heap of refuse in the streets and road medians unattended over a period of time. Considering the charges paid by residents on weekly generated waste, those who reside in a block of flats who are the dominant (55% in Ikeja and 48% in Ojo) pay as high as #700, residents of a single room (the least dominant in Ikeja at 13%) pay #200, while residents who operate a local shop attached to a residential building (the least dominant in Ojo) pay #300. Meanwhile, findings on the availability of transfer loading stations in close proximity to residents show that the majority (80%) of the residents of Ikeja have access to close-range transfer loading stations.

Table 3: Performance of Waste Collectors (PSP Operators) in Waste Management Logistics

Variables	**Ikeja LGA**					**Ojo LGA**			
Pick Up Time	Weekly Operation	Freq	%	Monthly Payment	Freq.	Freq	%	Monthly Payment	Freq.
	Once in a Week	248	68	Regular	75	248	79	Regular	80
	Twice a Week	95	26	Not regular	25	38	12	Not regular	20
	Thrice a Week	21	06	Total	100	28	09	Total	100
	Total	**364**	**100**			**314**	**100**		
User Charges/Billing	Flat	200	55	#700/Flat	#140000	151	48	#700/Flat	#105700
	Tenement Building of Eight Rooms	47	13	#200/room	#75000	88	28	#200/Room	#140800
	Shops	117	32	#300/Shop	#35100	75	24	#300/Shop	#22500
	Total	364	100		#250100	314	100		#269000
Is there any Transfer Loading Station close to you?	Yes	80	22			38	12		
	No	284	78			276	88		
	Total	364	100			314	100		

4.4 Factors Affecting the Performance of Waste Collectors in Waste Management Logistics in the Study Area

The factors affecting the performance of waste collectors in household waste management logistics in the study area were examined based on the perception of the residents who evaluated the performance of the PSP operators. The analysis was conducted using the Perceived Severity Index (PSI) based on the 5-point Likert scale gradation values consisting of Not at all a problem (N = 1), Minor Problem (MIP = 2), Moderate Problem (MP =3), Serious Problem (SP = 4) and Very Serious Problem (VSP = 5). For ease of measurement, the severity was measured using an index tagged PSI. To arrive at the PSI, a weighted value of 1, 2, 3, 4, and 5 was attached to each of the ratings as listed above, and the summation of the weight value (SWV) was obtained. The SWV was arrived at through the addition of the product of the number of responses to each aspect and the respective weight value attached to each rating. This is expressed mathematically as thus:

SWV = $\sum_{\mathrm{l}=1}^{5} X_i\, Y_i$

Where:

SWV = Summation of Weight Value,

X_i = number of respondents to rating i

Yi = the weight assigned a value (i= 1, 2, 3, 4, and 5)

The SWV was then divided by the number of respondents to arrive at each perceived severity index (PSI). The analysis, which was expressed quantitatively as 'PSI' = $\frac{\mathrm{SWV}}{\sum_{\mathrm{i}=1}^{5} i= X_i}$. Using the above analytical method, the mean index presented in Table 4 revealed 3.1249, and this was used to compare the

severity of all variables under consideration. Accordingly, Table 4 shows that transport distance covered (3.8879), environmental attributes (3.8097), inadequate waste transfer stations in close proximity (3.7301), irregular financial commitment of residents (3.6077), and local customs and cultural practices (3.1222) are major factors affecting the performance of waste collectors in waste management logistics across the study area. However, poor facility funding support (2.8864), PSP operator attitude and excess (2.8732), poor waste sorting and storage (2.5015), poor community awareness and input (2.4749), and law and policies governing coverage areas (2.3156) were the factors that had the least impact on PSP operation in waste management logistics activities in the study area.

Table 4: Factors affecting the performance of waste collectors in waste management logistics

Factors	NAP	MIP	MOP	SP	VSP	TWV	RIM	MIV	RK
Inadequate waste transfer stations in close proximity	21	80	408	1540	480	2529	3.7301		3
Poor community awareness and input	258	298	207	380	535	1678	2.4749		9
Poor waste sorting and storage	344	180	33	104	1035	1696	2.5015		8
Law and policies governing coverage areas	273	340	237	240	480	1570	2.3156	3.1249	10
Transport distance	67	0	0	1944	625	2636	3.8879		1
Poor facility funding support	186	232	267	652	620	1957	2.8864		6
Local customs and cultural practices	135	28	843	408	730	2144	3.1622		5
Environmental attributes	61	242	162	368	1750	2583	3.8097		2
Attitude and excess of the PSP operators	135	290	612	236	675	1948	2.8732		7
Irregular financial commitment of residents	18	292	357	784	995	2446	3.6077		4

Authors' Survey, April (2020)

4.5 Activities of Private Sector Participation (PSP) in Waste Management Logistics

4.5.1 Logistics of Waste Generation and Disposal by PSP Operators

Further investigations were conducted to understand the logistics of waste generation and disposal based on the structured interview conducted with the PSP operators covering Ikeja and Ojo LGAs in the study area. According to Table 5, the total monthly household waste generated in Ikeja LGA was 1,555,254.5Kg (1555.3metric tons) and 1,233,459Kg (1,233.5metric tons) in Ojo LGA. Also, from the results presented in Table 5, the majority of households' waste generation per week ranges between 121kg and 160kg in study areas. This is due to the fact that the majority of respondents are working class and earn above the just newly introduced #30,000 minimum wage in Nigeria. If the recent population growth rate of Lagos is anything to go by, by the year 2025, waste generation might have tripled, hence the need to have a proper and functional waste management strategy and system to keep pace with the trend. An interview with Private Sector Participation (PSP) drivers/operators revealed that it takes an average of 3.7 hours for a compactor or garbage truck to load and offload garbage at Olusosun due to traffic gridlock and the unbearable terrain at the landfill. The waiting hours at Olusosun Landfill to offload a compactor is about 2 hours and 30 minutes. Also at Solous 3, to load and offload trucks takes an average of 7 hours for just a trip. The situation at the Solous 3 Landfill is so terrible that it takes almost 6 hours to offload when at the dumpsite due to the poor road situation within the dumpsite and the nature of the terrain. When comparing the situation at both landfills, it is easier to dump at Olusosun Landfill with less time than Solous.

The weekly expenditure on fuel, vehicle operation and maintenance were #7533 and #1733, making a total sum of $19666/day in Ikeja LGA as against #9433 and #6500, making a total sum of $15933/day in Ojo LGA. This is caused by the long distance travelled between the waste generation point and the landfills. The cost incurred by PSP operators is very high and this might put them out of business if the government did not intervene in providing subsidies and reductions in charges paid to the government. There is a great concern that these heavy trucks might have an adverse effect on the environment due to their high fuel consumption and poisonous gases emitted by the trucks. The study revealed that, to achieve an effective waste management system, route optimization and fleet optimization are inevitable to reduce operational costs incurred by PSP operators. It is worthy of note that out of 16 official dumpsites in Lagos, only five (5) are very active till date. They are: Olusosun, Soluos 2, Soluos 3, EwuElepe and Epe. And non-functional dumpsites are: Solous 1, AbuleEgba, Owutu, Ogombo, Anthony Village, Isolo, Makoko, Adeniji Adele, Agunlejika, Omole, and Billings Way. Furthermore, waste is stored mostly through steel, concrete, or synthetic containment either in our homes or at the designated points around town for onward transfer to the landfills. Earthen impoundments are used for the

storage of animal waste, while waste holding ponds are used to store storm water runoff, which should not be allowed to flow uncontrolled into the external environment because the runoff contains organic substances that are very harmful.

Table 5: Logistics of Waste Generation and Disposal

Variable	Indices	Ikeja LGA		Ojo LGA	
		Average Waste (Daily)	Average Waste (Monthly)	Average Waste (Daily)	Average Waste (Monthly)
Volume of Waste	< 80kg	2,080	64,480	1,760	54,560
	81-120kg	402	12,462	11,155.5	345,820.5
	121-160kg	41,447.5	1,284,872.5	15,033.5	466,038.5
	> 160kg	6,240	193,440	11,840	367,040
	Total	50,169.5	1,555,254.5	39,789	1,233,459
Turnaround Time of Truck	2 Hours	6	40	-	-
	4 Hours	5	33	-	-
	6 Hours	4	27	7	47
	8 Hours	-	-	8	53
	Average Turnaround Time	3.7 Hours		7.06 Hours	
	Total	15 PSP Operators		15 PSP Operators	
Route Optimization	Average fuel consumption/5km	40liters		53liters	
	Average Cost of Vehicle Repair/Day	#11,733/Day		#20,950/Day	

Source: Authors Field Survey, 2020

4.5.2 Frequency of Waste Collection by PSP Operators in Ikeja LGA and Ojo LGA

Total waste generated in Ikeja and Ojo shows that not all the waste generated monthly is totally evacuated by PSP operators. The findings presented in Table 6 show that a total of 1555.3metric tons were generated in Ikeja and only 615metric tons were evacuated with forty-one (41) trips using garbage trucks of 15-ton capacity, and the left-over of 940.3metric tons was unattended to. Also, at Ojo, the total waste generated is 1233.5metric tons and 870metric tons are evacuated with 58 truck trips in a month with left-over waste of 363.5metric tons. To successfully evacuate waste in Ikeja LGA without left-over, the operators needed to make a trip of at least 104 trips per month to evacuate 1555.3metric tons, while Ojo needed 82 trips to evacuate a total waste of 1233.5metric tons. The inability to completely evaluate the waste generated is attributed to the distance covered and turn-around time of trucks at the transfer stations as well as the poor attitude of the residents, particularly in the area of financial commitment and cooperation.

Corroborating the latter using the field observation records of the researchers, they noted that there is a great deficiency in the number of vehicles engaged in waste disposal. Hence, there is an obvious ineffectiveness in the waste disposal system noticed in the study area and the delay in collection of household waste for days, weeks, or months, resulting in pollution and littering of the surroundings. The PSP operators were of the opinion that the locations of sanitary landfills are far away from some neighborhoods, and the gridlock as well as environmental conditions in the neighborhood impede smooth logistics of refuse from collection point to dumpsite. Meanwhile, the nature of road design and condition, neighborhood design, and road users' attitude compounded the longer hours of travel and distance covered from the point of waste generation to the waste transfer station, landfill, or recycling plant. These factors are noted as major factors militating against effective management of waste logistics.

Table 6: Frequency of Waste Collection by PSP Operators (Trip Making)

Operator	Landfills	Volume of waste generation monthly (metric tons)	Frequency of trips (monthly) by 15 tons capacity truck	Waste collected monthly (15 tons capacity truck)	*Left over waste (uncovered for)	*Total trips expected to take care of total waste generated monthly	*Variance in monthly trips
PSP Operators	Ikeja	1555.3	41	615	940.3	104	63
	Ojo	1233.5	58	870	363.5	82	24
	Total	2788.8	119	1485	1303.8	186	87

Source: Field Survey, 2020 (* PSP Operators; **Authors Calculation)

4.6 Factors Determining the Best Practices in Waste Management Logistics

The PSP operators involved in the waste management collection and disposal within the study area were interviewed on the factors perceived to determine the best practices in waste management logistics and the analysis was achieved using the frequency of opinion presented in Table 7. Findings presented in Table 7 revealed quality transport options as the most rated factor (100%) that determines best practices in waste management logistics. Worthwhile, this is followed by route optimization and distance coverage (93%), quality of waste sorting and handling (93%), quality of inventory control and management (87%), vehicle type and condition (87%), and waste storage and processing (87%). In other words, the quality of waste packaging (33%) and the nature of waste marketing and recycling (27%) play the least role in waste management logistics best practices in the study area. In other words, it is worth knowing that eight (8) out of the ten (10) factors scored above 75%, indicating the best possible factors that significantly affect waste management logistics best practices in the study area.

Table 7: Analysis of factors determining best practices of waste management logistics

Indicators	**NO**		**YES**		**TOTAL**	
	Freq.	%	Freq.	%	Freq.	%
Customer information	5	33	10	67	15	100
Inventory control and management	2	13	13	87	15	100
Storage facilities	3	20	12	80	15	100
Waste packaging	10	67	5	33	15	100
Quality transport option	0	0	15	100	15	100
Route optimization	1	7	14	93	15	100
Waste marketing and recycling	11	73	4	27	15	100
Vehicles type and condition	2	13	13	87	15	100
Quality of waste sorting/ handling	1	7	14	93	15	100
Waste storage and processing	2	13	13	87	15	100

4.7 Constraints to Waste Management Logistics in the Study Area

There are numerous challenges identified as affecting waste logistics, in particular, and waste management in the study area. All stakeholders, including PSP operators and members of the general public, are facing the same challenges and consequences. In view of this, the constraints to waste management logistics operations as observed by the PSP operators include the following:

- The deplorable condition of the landfills failed to support efficient waste logistics. The situation is more worrisome during the rainy season as the rough terrain is mostly unsuitable for waste trucks and refuse compactors, which leads to increased turnaround time for the service providers. This is an attestation that landfills are poorly maintained, while the costs incurred on repairs and services of refuse compactors become outrageous as a result of poor management of the dumpsite to offload.
- The persistent delay in payment of service providers is very worrisome and also has adverse implications for waste logistics and transportation. Accordingly, debts and delays in payment of charges by users and the government are inconsequential to efficient waste logistics.
- The exorbitant price of the garbage compactors being provided by the government is having adverse implications for waste logistics and the overall waste management framework. This has been leading to the inability of the operators to liquidate the payment of the hired purchased vehicles since there is no provision for any subsidy or incentive with respect to spare parts and other essential equipment.
- The government's policy on waste management initiatives is defective and inconsistent. To be more specific, government policy has always changed without due consultation with stakeholders in order to foster a sense of belonging, while the construction of transfer loading stations (TSL), etc., no longer serves its purpose because service providers now dump directly to dumpsites rather than through transfer stations.
- Some of Lagos's hinterland is inaccessible to operators due to bad roads, and the cart pushers who would assist in such cases have been banned by the government to make

way for PSP operators. There is also a dearth of manpower in waste handling procedures. The operators just jump into the business without understanding what it takes to start the business.

- The billings and charges being used by the operators are not a reflection of the true situation in the area as fixed rates per flat, shop, and room are being charged rather than charges based on the amount of waste generated by a household or house.

5. Conclusion and Recommendations

This study examined waste management logistics, which has always been a major problem and a serious challenge confronting mostly urban dwellers, society, and governments. The issue of waste management logistics is also of utmost concern to many international organisations such as the World Bank and the United Nations. This improper collection and disposal of waste and the attributed defective mechanism of waste management, especially in developing countries, is no doubt adversely affecting residents in the built environment, leading to the emergence of concerns. With Nigeria's cities, most especially Lagos Metropolis, growing with an unprecedented population growth, urbanization, a booming economy, improved standard of living and the influx of people to cities for greener pastures, there has been an accompanying increment in the volume of waste generation while waste disposal mechanisms and management logistics of such have not been effective.

Like Fasina, Salisu, & Akanmu (2020), this study established the importance of waste logistics in achieving effective waste management practices in Nigeria's cities. Therefore, it becomes expedient to adequately understand the nature and characteristics of waste management; management of waste logistics, which includes waste collection, storage, transportation, and disposal; and the factors determining the best practice of waste logistics in the Lagos Metropolis. Therefore, the study concludes that the logistics of waste management in the study area is constrained by so many salient factors. Obviously, there is a near absence of synergy among the logistics components of waste management while there is a lack of a framework for waste management logistics in Nigeria; hence, the need for reappraisal and reawakening in line with best practices to solve logistics weaknesses in waste management practices in Lagos Metropolis and the country at large.

Therefore, it was recommended, among others, that there is a need for training and retraining of manpower in waste logistics to foster sustainable waste management in the country, apart from the intensification of public enlightenment on contemporary waste management practices. This would equally improve waste information, collection, handling and processing, transportation and disposal, inventory control management, and storage as critical components of waste logistics, which households and other stakeholders must take to heart towards achieving sustainable waste management. Also, adequate route optimization towards a reduction in fuel consumption and turnaround time of garbage trucks to landfills is anticipated by this study, while incentives and funding support for private operators would serve as veritable encouragement to operators to achieve the goal of a clean built environment in Nigeria.

In addition, all the landfills in Lagos Metropolis should be made functional and more transfer stations should be established in close proximity with the physical development plan to reduce turnaround time of waste vehicles, avoid longer travel time and encourage fleet and route optimization. In addition, review of waste management policy with incursion of waste logistics as integral component has become indispensable considering the numerous challenges associated with evacuation, handling, movement and disposal of waste at dumpsites; hence, formulation of workable policy and broad strategies for sustainable waste management in this regard is highly articulated by this paper.

Finally, the society should be enticed into waste market so as to fully explore immensurable potentials that are available in waste market through waste to wealth initiative. With this, households waste would over accumulated before evacuating, and at the same time, guide against littering the streets with garbage as health hazard due to pollution or offensive odour and contamination of underground water would be curtailed. As a result, the populace would be willing to devise means at eliminating waste through action and inaction and the desire to eco-friendly built environment shall be achieved.

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