Research Article

Intraurban Analysis of Domestic Solid Waste Disposal Methods in a Sub-Sahara African City

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Received 17 August 2014; Revised 10 November 2014; Accepted 23 November 2014; Published 18 December 2014

Academic Editor: Brajesh Dubey

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The study examined the influence of socioeconomic attributes of residents on domestic solid waste disposal methods in Lagos metropolis, Nigeria. Primary data for the study were obtained through questionnaire administered on residents in Eti-Osa, Ikeja, and Mushin Local Government Areas (LGAs) representing the low, medium, and high densities, respectively, into which the sixteen LGAs in Lagos metropolis were stratified. One out of every four wards in each LGA was selected for survey. From a total of 15,275 residential buildings in the ten wards, one out of every forty buildings (2.5%) was selected using systematic random sampling where a household head was sampled. Information obtained includes the residential characteristics and the disposal methods. Enquiries into the socioeconomic attributes of the residents showed that 59.9% were high income earners and 76.6% had attained tertiary school education. This study concluded that six disposal methods were common in the study area. Furthermore, through multinomial logistic regression, the influence of socioeconomic characteristics of residents (density, income, age of respondents, educational status, and length of stay) on domestic solid waste disposal methods varied significantly in Lagos metropolis. The study established that most of the solid waste disposal methods utilized by residents in Lagos metropolis were not environment-friendly.

1. Introduction

The rapid urbanization experiencing in the cities of the world has accentuated for a plethora of environmental challenges within the different residential spheres. These problems include urban sprawl, decaying inner-city, inadequate housing, crime, and congestion, among others. Of pertinent attention is the problem associated with waste management that is taking unprecedented complex dimension in the cities of developing nations. From engineering to behavioral science, how waste can be properly managed has become a germane issue via several studies [1–4].

An elaborate definition of the term waste embraces all unwanted and economically unusable by-products or residuals at any given place and time and any other matter that is discarded into the environment [5, 6]. This definition suggested that what constitutes waste must occur in such a volume, concentration, constituency, or manner as to cause a significant alteration in the environment. Thus, apart from waste being an unwanted substance that is discarded, the amount of it and the impact it makes on the environment

also become important considerations in defining waste. Events of the late 20th and early 21st centuries indicate that waste, in whatever form or classification: solid, liquid, or toxic, has become a major consequence of modernization and economic development [7]. Notably, the solid form of waste is fast becoming a menace in both developed and developing nations [8, 9].

As observed by past study [10], in countries around the world, one major environmental problem that confronts municipal authorities is solid waste management. The study posited that city governments and dwellers are confronted by mounting problems regarding the solid waste generation. The observation is in tandem with the assertion of other studies [11, 12] that, in third World cities, between one-third and one-half of the solid wastes generated remain uncollected. In high-income countries, the issues associated with solid waste usually centre on the difficulties and high cost of disposing the large quantity of solid waste generated from different sources. Extant study [13] posited that of striking concern are the management problems associated with the solid waste emanating from domestic sources.

The management of domestic solid waste is one of the huge challenges of the urban areas of all sizes. From megacities to the small towns, it is always in the top five of the most challenging problems for city managers [12]. Independent studies [14–16] noted that the disposal of domestic solid waste generated is particularly problematic in cities of developing countries. In this regard, Nigeria is not exempted as evidences abound that the problems associated with poor domestic solid waste disposal are daily realities in most Nigerian cities.

The disposal of solid waste is the ultimate stage in solid waste management system, influenced by factors such as characteristics of waste to be disposed, cost consideration, availability of disposal site, cost of labour, and technical implication of methods of disposal [17]. Past studies established that the disposal methods often utilized include the use of sanitary landfill, composting, incineration, and pyrolysis. These methods are commonly used in developed countries [18–20].

There are other solid waste disposal methods mainly employed in developing nations [17, 21–23]. These methods include the use of designated and incidental open spaces, dumping of waste into drain during and after rainfall, on river banks, beside road, and burning and burying. Others include the use of uncompleted building, vacant land, and collection by government refuse van, private waste managers, and cart pushers. These methods are considered both naive and dangerous, as they are environmentally unfriendly [24–27]. Based on the above, the available methods of solid waste disposal are investigated in Lagos metropolis in this study.

Therefore, this study is different from the above empirical studies because it attempted to provide answer to these research questions: Is there any significant difference in the solid waste disposal methods utilized by residents within the residential neighborhoods of Lagos metropolis? To what extent can the socioeconomic attributes of residents influence their methods of solid waste disposal in Metropolitan Lagos? Successfully providing answers to these questions will be pivotal to suggesting feasible measures to address challenges associated with domestic solid waste disposal in Lagos metropolis, a city regarded as one of the fastest growing megacities in the world. Thus, the study aimed at examining the influence of socioeconomic attributes of residents on the choice of solid waste disposal methods utilized in Lagos metropolis, Nigeria. This is with a view to provide information that can enhance solid waste management.

2. Materials and Method

Lagos is situated within latitudes $6^{\circ}23'N$ and $6^{\circ}41'N$ and longitudes $2^{\circ}42'E$ and $3^{\circ}42'E$. The physical growth and development of Lagos are tied to its expanding economic and political roles, which aided by its rapid and explosive population growth has been phenomenal. The state has a population of 17 million with approximately 85% living in the city of Lagos making it one of the most urbanized regions in Nigeria. The population density of the state is about 4,193 persons per square km. However, in the built-up areas of Metropolitan Lagos, the average density is over 20,000 persons per square km. The rate of population growth is about

600,000 per annum, which is ten times faster than that of New York and Los Angeles [28].

Lagos metropolis is the economic and financial capital of Nigeria. With a total of 999.6 km^2 in land area, the metropolis is made up of 16 Local Government Areas (LGAs) [29]. Eti-Osa LGA has the largest land area of 299.10 km^2 ; the second and the third largest are Ojo and Alimosho LGAs with 182 km^2 and 137.8 km^2 , respectively. The total population that made up the metropolis has the largest concentration at Alimosho LGA (2,047,026) while the second and third in terms of population size are Ajeromi-Ifelodun LGA (1,435,295) and Mushin LGA (1,321,517) [30].

Data for this study were from primary and secondary sources. The primary data was sourced through questionnaire administration and actual measurement of household solid waste generated in the study area. Through multistage sampling technique, the 16 Local Government Areas (LGAs) within Lagos metropolis were stratified into low, medium, and high density areas. In this study, a LGA with a population of 20–10,000 persons/ km^2 was regarded as low density, while medium and high density have 10,001–20,000 persons/ km^2 and above 20,000 persons/ km^2 , respectively. Simple random sampling technique was used to select Eti-Osa, Ikeja, and Mushin areas from the low, medium, and high density areas, respectively. The three selected LGAs were further stratified into existing electoral wards as recognized by the Independent National Electoral Commission (INEC) [31].

Information obtained from INEC showed that there were fourteen electoral wards in Mushin LGA, while Ikeja and Eti-Osa LGAs have ten (10) wards each. One out of every four (4) wards in each LGA was selected through simple random sampling without replacement. Thus, ten (10) political wards were surveyed. There were 15,275 residential buildings in the selected political wards, with 8996, 3780, and 2499 in the high, medium, and low densities, respectively. Systematic random sampling technique was adopted in selecting one out of every forty buildings (2.5%).

Using this method, a total of 384 buildings were sampled with a household head targeted in each building for questionnaire administration. Information obtained from residents includes their socioeconomic attributes and methods of solid waste disposal.

3. Results and Discussion

The socioeconomic attributes of the residents were considered important for this study. The frequency as well as percentage distribution of the variables examined across the different residential densities is summarized in Table 1. Income of respondents is a strong determinant of the manner with which residents of any given community manage their solid waste. In this study, the income groups for household heads were based on the income classification adapted from past study using the Lagos State Civil Service minimum wage as the benchmark [32, 33]. Therefore, household heads who earn ₦18,780–₦50,000 were regarded as low income earners (LI), and ₦50,001–₦100,000 were referred to as middle income earners (MI), while the high income earners

TABLE 1: Socioeconomic characteristics of residents in the study area.

Variables	High		Medium		Low		Total	
	Freq.	(%)	Freq.	(%)	Freq.	(%)	Freq.	(%)
Income classification								
₦18,780–₦50,000 (LI)	12	5.3	8	8.5	—	—	20	5.2
₦50,001–₦100,000 (MI)	88	38.4	46	48.9	—	—	134	34.9
Above ₦100,000 (HI)	129	56.3	40	42.6	61	100	230	59.9
Age of residents								
19–30 years	32	14.0	5	5.3	12	19.7	49	12.8
31–55 years	167	72.9	69	73.4	35	57.4	271	70.6
56 and above	30	13.1	20	21.3	14	23.0	64	16.7
Educational status								
Primary school	1	0.4	4	4.2	—	—	5	1.3
Secondary school	51	22.3	30	31.9	4	6.6	85	22.1
Tertiary school	177	77.3	60	63.9	57	93.4	294	76.6
Length of stay								
1–10 years	149	65.0	67	71.3	47	77	263	68.5
11–25 years	78	34.1	25	26.6	14	23.0	117	30.5
26–40 years	—	—	2	2.1	—	—	2	0.5
Above 40 years	2	0.9	—	—	—	—	2	0.5

Note: Freq. means frequency.

(HI) earn above ₦100,000. Low residential density had the largest proportion of respondents with high income. This group accounted for 100%. Residents in the high and medium residential densities with high income were 56.3% and 42.3%, respectively. Also, the analysis of the residents that were middle income earners was 48.9% and 38.4% in the medium and high densities, respectively. This study posited that 59.9% of the residents in Lagos metropolis were high income earners.

The age of the household heads in the identified residential densities of Lagos metropolis was grouped into three. These were 19–30 years (the youths), 31–55 years (the young adults), and 56 and above (the adults) [34, 35]. This study established that 70.6% of respondents in Lagos metropolis were young adults. The youth and adult respondents accounted for 12.8% and 16.7%, respectively. However, analysis of the age distribution of residents within the identified residential densities revealed that young adults were dominant in the three residential densities. This age group constituted 72.9%, 73.4%, and 57.4%, respectively in the high, medium, and low residential densities. Next in descending order were the adults. This group of respondents accounted for 13.1%, 21.3%, and 23.0% in the high, medium, and low residential densities, respectively.

Information on the educational status of respondents in the study area indicated that 76.6% of the respondents had tertiary educational qualification, while 22.1% had secondary school qualification. However across the three residential densities, majority of the respondents in the high and medium densities had tertiary educational qualification. This accounted for 77.3% and 93.4%. The highest proportion of respondents with secondary school qualification was 22.3% and 31.9% in the high and medium densities, respectively.

The number of years a respondent has been living in the area was also investigated. This is referred to as the length of stay. The number of years a household has been living in an area was therefore categorized into four: that is, 1–10 years, 11–25 years, 26–40 years, and above 40 years [33]. Enquiry into this socioeconomic attribute showed that 68.5% of the respondents had lived in their residential area for 1–10 years. However, analysis of the age distribution of residents within the identified residential densities revealed that 34.1%, 26.6%, and 23% of the respondents had lived for 11–25 years in the high, medium, and low residential densities, respectively.

3.1. Analysis of Domestic Solid Waste Disposal Methods in the Study Area. As shown in Table 2, six major disposal methods were common in the study area. The use of accredited private sector participation (PSP) accounted for 25.9% of disposal methods in high, 26.1% in the medium, and 38.6% in the low density areas. Similarly, as a form of social service and environmental management initiative provided by the Lagos State Government, 16.2%, 10.5%, and 27.2% of the residents in the high, medium, and low densities, respectively, indicated that they often disposed their solid waste in Lagos State Waste Management's (LAWMA) refuse facility. Despite the above findings, the study still established that indiscriminate waste disposal was prevalent in Lagos metropolis. This assertion is premised on the fact that (21.9%, 21.1%, and 22.7%) of the residents disposed solid waste on the road in the high, medium, and low densities, respectively: a proportion as high as 16.5% and 18% of the residents dumped waste in the drain during rainfall.

Burning as a form of disposal practice accounted for 8.4% and 11.5% in the high and medium densities, respectively. The dumping of waste on open space was a practice found

TABLE 2: Solid waste disposal methods in the different residential densities.

Disposal methods	High		Medium		Low		Total	
	Freq.	(%)	Freq.	(%)	Freq.	(%)	Freq.	(%)
Burning	28	8.4	23	11.5	—	—	51	8.23
LAWMA ** refuse facilities	54	16.2	21	10.5	24	27.2	99	15.9
Accredited PSP ***	86	25.9	52	26.1	34	38.6	172	27.7
Sometimes on the road	73	21.9	42	21.1	20	22.7	135	21.8
Dump in the drains during rainfall	55	16.5	36	18.0	—	—	91	14.7
Nearby open space	36	10.8	25	12.5	10	11.3	71	11.5
Total	332	100	199	100	88	100	619*	100

*This exceeded number of questionnaires administered because residents adopted more than one method of disposal.

**LAWMA means Lagos State Waste Management Agency.

*** PSP means private sector participation.

TABLE 3: Multinomial logistic regression model of association between solid waste disposal methods and socioeconomic characteristics of residents.

Parameters	Exp(β)	Burning		LAWMA refuse facilities			Accredited PSP		
		95% CI for Exp(β)		Exp(β)	95% CI for Exp(β)		Exp(β)	95% CI for Exp(β)	
		Lower	Upper		Lower	Upper		Lower	Upper
Residential densities									
Low	1.000	—	—	1.000	—	—	1.000	—	—
Medium	.000	.000	—	.666	.356	1.246	1.707	.910	3.202
High	.396	.214	.733	.405	.228	.719	1.643	.951	2.839
Income group									
Low income	1.000	—	—	1.000	—	—	1.000	—	—
Middle income	2.616	.922	7.423	.745	.335	1.659	2.693	1.181	6.140
High income	.727	.386	1.366	2.320	1.248	4.312	1.037	.576	1.866
Age group									
19–30 (youths)	1.000	—	—	1.000	—	—	1.000	—	—
31–55 (young adults)	.000	.000	—	.467	.177	1.233	.629	.238	1.663
56–65 (adults)	1.248	.544	2.866	.582	.257	.993	1.716	.858	3.432
School educational status									
Primary school education	1.000	—	—	1.000	—	—	1.000	—	—
Secondary school education	.000	.000	—	.401	.038	4.195	1.619	.160	16.339
Tertiary school education	.606	.278	1.317	.505	.257	.993	1.522	.794	2.917
Length of stay									
1–10 years	1.000	—	—	1.000	—	—	1.000	—	—
11–25 years	.000	.000	—	1.650E9	.000	—	.950	.058	15.574
26–40 years	.000	.000	—	1.120E9	.000	—	1.160	.069	19.635
Model χ^2 (–2log likelihood)	34.713			49.883			49.638		
N	51			99			172		

in all the three residential densities. It however accounted for 10.8%, 12.5%, and 11.3% of all the disposal methods in the high, medium, and low residential densities, respectively. The disposal of waste on vacant plots of land was common in places where landholders were yet to develop such land. It can be deduced from Table 2 that dumping of waste in run-off water especially during the rainy season was a means of disposal which in the high and medium densities accounted for 16.5% and 18%. This analysis confirmed that most of the solid waste disposal methods utilized by the resident in Lagos metropolis were not environment-friendly.

Based on the above, this study examined the influence of certain socioeconomic variables on the disposal methods employed by residents. This was determined through Multinomial Logistic Regression Analysis as shown on Tables 3 and 4. The statistical technique was employed because categorical variables were to be analyzed. Each of the solid waste disposal methods was selected as dependent variables. Five other sets of variables were the predictors. These are residential density, income group, age group, educational status, and length of stay. Fifteen categories were further derived from these variables: residential density was classified into “low”

TABLE 4: Multinomial logistic regression model of association between solid waste disposal methods and socioeconomic characteristics of residents.

Parameters	Exp(β)	Roadside		Dumping in the drains			Nearby open space		
		95% CI for Exp(β)		Exp(β)	95% CI for Exp(β)		Exp(β)	95% CI for Exp(β)	
		Lower	Upper		Lower	Upper		Lower	Upper
Residential densities									
Low	1.000	—	—	1.000	—	—	1.000	—	—
Medium	.364	.190	.697	.364	.190	.697	.190	.087	.415
High	3.670	2.029	6.637	3.670	2.029	6.637	1.086	.639	1.845
Income group									
Low income	1.000	—	—	1.000	—	—	1.000	—	—
Middle income	.243	.107	.553	.243	.107	.553	.795	.359	1.757
High income	.743	.404	1.366	.743	.404	1.366	.902	.504	1.614
Age group									
19–30 (youths)	1.000	—	—	1.000	—	—	1.000	—	—
31–55 (young adults)	.543	.196	1.505	.543	.196	1.505	.225	.076	.665
56–65 (adults)	.479	.225	1.022	.479	.225	1.022	.759	.377	1.530
School educational status									
Primary school education	1.000	—	—	1.000	—	—	1.000	—	—
Secondary school education	3.534	.348	35.902	3.534	.348	35.902	1.456	.222	9.526
Tertiary school education	.478	.242	.944	.478	.242	.944	.584	.302	1.132
Length of stay									
1–10 years	1.000	—	—	1.000	—	—	1.000	—	—
11–25 years	1.322	.081	21.685	1.322	.081	21.685	1.825E9	.000	—
26–40 years	.716	.042	12.190	.716	.042	12.190	2.036E9	.000	—
Model χ^2 (–2log likelihood)	49.341			36.350			47.450		
N	135			91			71		

“medium” and “high”; income had three groups as well: “low,” “medium,” and “high,” while the age group was divided into 19–30 (youths), 31–55 (young adults), and 56–65 (adults) [32]. Others were educational status of residents from which three categories were derived thus primary school education, secondary school education, and tertiary education, and lastly residents’ length of stay was categorized into 1–10 years, 11–25 years, 26–40 years, and above 40 years [33]. Six major solid waste disposal methods were identified in Lagos metropolis. The summary of the Multinomial Logistic Regression Analysis on each of the disposal methods is thus presented.

Among the residents, the likelihood of burning as a disposal method was peculiar to all the categories of the independent variables. The model χ^2 (–2log likelihood) = 34.713 was significant at 0.001 confirming that there was a significant relationship between burning as a waste disposal method and the independent variables. Residents in the high density had an odd ratio of .395; 2.616 was associated with middle income category, and the adults with age range of 56–65 years and residents with secondary school education were 1.248 and .606 times more likely to utilize this disposal method.

The model fitting information of χ^2 (–2log likelihood) = 49.883, significant at 0.001, established that a significant relationship also existed between the dependent and independent variables. Among the residents, the likelihood of

using LAWMA refuse facilities as a disposal method waste was peculiar to all the categories of the independent variables. Residents in the medium density had an odd ratio of .666; 2.320 was associated with high income category, and the adults (56–65 years) and residents with tertiary education were .582 and .505 times more likely to utilize this receptacle, while residents who have lived for 26–40 years were 1.650 times more likely to utilize LAWMA facilities as a solid waste disposal method.

The model χ^2 (–2log likelihood) = 49.638, significant at 0.001, established that a significant relationship existed between the dependent and independent variables. The likelihood of using accredited PSP as a disposal method was peculiar to all the categories of the independent variables. Residents in the medium density had an odd ratio of 1.707; 2.693 was associated with middle income category, and the adults (56–65 years) and residents with secondary school education were 1.716 and 1.619 times more likely to use this receptacle, while residents who have lived for 26–40 years were 1.160 times more likely to make use of this receptacle.

Among the residents, the likelihood of dumping solid waste on the roadside as a disposal method was peculiar to all the categories of the independent variables. The model χ^2 (–2log likelihood) = 49.341 was significant at 0.001 confirming that there was a significant relationship between the dependent variable and the independent variables. Residents

in the high density had an odd ratio of 3.670; .743 was associated with high income category, and the adults with age range of 31–55 years and residents with secondary school education were .543 and 3.534 times more likely to use this disposal method, while residents who have lived for 11–25 years were 1.322 times more likely to make use of this disposal method.

The model χ^2 ($-2\log$ likelihood) = 49.341, significant at 0.001, established that a significant relationship existed between the dependent and independent variables. The likelihood of dumping household solid waste in the drains as a disposal method was peculiar to all the categories of the independent variables. Residents in the high density had an odd ratio of 3.670; .743 was associated with high income category, and the young adults (31–55 years) and residents with secondary school education were .543 and 3.534 times more likely to resort to this adverse disposal method, while residents who have lived for 11–25 years were 1.322 times more likely to make use of this receptacle.

The model fitting information of χ^2 ($-2\log$ likelihood) = 47.450, significant at 0.001, established that residents in the high density had an odd ratio of 1.086; .795 was associated with high income category, and the adults (56–65 years) and residents with secondary school education were .759 and 1.456 times more likely to resort to this deleterious disposal method of dumping in nearby open space, while residents who have lived for 26–40 years were 2.036 times more likely to make use of this disposal method. It could be concluded from the foregoing that significant relationship existed between the solid waste disposal methods and with the socioeconomic of residents in Lagos metropolis. The study further posited that most of solid waste disposal methods utilized in Lagos metropolis were not environment-friendly. This was confirmed by 56.2% of the respondents.

4. Conclusions

This study concluded that six major disposal methods were common in the study area. Furthermore, the influence of socioeconomic characteristics of residents (density, income, age, educational status, and length of stay) on domestic solid waste disposal methods varied significantly in Lagos metropolis.

Consequently, this study suggests a consistent public enlightenment and environmental sensitization for all citizens. This type of education should present the benefits and dangers attached to making the environment clean and otherwise. It should also be an avenue through which residents would be educated on their roles in achieving a clean and healthy living environment through healthy solid waste disposal methods. National Orientation Agency (NOA), government agency such as Lagos State Waste Management Agency (LAWMA), Lagos State Ministry of Environment, Federal Ministry of Environment, and Local Government Authorities can also collaborate with other non-governmental organization and citizen group, such as Citizen Advisory Group [17], to develop modalities for informed environmental sensitization. Such enlightenment initiatives become highly imperative as majority of the respondents in

the study area confirmed that significant proportion of solid waste disposal methods utilized in Lagos metropolis were not environment-friendly.

Conflict of Interests

The research being reported in this paper emanated from Effect of Residential Characteristics on Household Solid Waste and Street Litter Management in Lagos Metropolis, Nigeria, a M.Sc. degree thesis, submitted by the author—Oluwale Samuel Ojewale—to the Department of Urban and Regional Planning, Obafemi Awolowo University, Ile-Ife, Nigeria, on 17th of July, 2014. The terms of this arrangement have been reviewed and approved by the Board of Examiners, Obafemi Awolowo University, Ile-Ife, Nigeria, on 4th of August, in accordance with its policy on objectivity in research.

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