GLOBAL JOURNAL OF ENGINEERING, DESIGN & TECHNOLOGY
(Published By: Global Institute for Research & Education)
www.gifre.org

Statistical Modeling of Anambra State Solid Waste Management Constraints

Ihueze, Christopher Chukwutoo & Chukwumuanya, Emmanuel Okechukwu
Department of Industrial/Production Engineering, Nnamdi Azikiwe University, Awka, Nigeria

Abstract

Numerous factors have been identified as hindrances in the efforts of solid waste managers to providing effective, efficient and sustainable solid waste management services in their localities. The study aimed at investigating the dominating ones in Anambra State, Nigeria. Four out of all the known constraints namely, insufficient funding, non-availability of vital tools/equipment, lack of modern technology and lack of data/improper data management were evaluated, verified and validated through a case study as being the dominants in the Anambra State solid waste management system. Should the state government adequately deal with these four constraints, about 85% of ASWAMA problems in providing sustainable quality services will be eliminated. Besides, the hypotheses drawn on the questionnaire confirmed funding as a serious factor for consideration in Anambra State SWM. Analysis made showed that the fund given to ASWAMA as annual budgetary allocation is not sufficient for the Agency to achieve its legal objectives.

Key words: Modeling, efficient, service delivery, constraints, hypotheses

1. Nomenclature

ASWAMA = Anambra State Waste Management Authority
ANSEPA = Anambra State Environmental Protection Agency
SWM = Solid waste management
NPC = National Population Commission
CBO = Community based organization
SWOT = Strengths, Weaknesses, Opportunities and Threats
% = Percent or percentage of
NGO = Non-governmental organization
n = Sample size
N = Population
e = Error term
1 = a constant
x^2 = Calculated value of chi square
f_o = Observed frequency
f_e = Expected frequency
$\sum$ = Sum of
TR = Total in row
TC = Total in column
GT = Grand total
d*f* = No. of degrees of freedom, R = No. of rows, C = No. of columns

2. Introduction

Urban solid waste management is considered as one of the most serious environmental problems confronting urban areas in developing countries (Pfammatter and Schertenleib, 1996; Sinha and Enayetullah, 2000; WRI et al., 1996; Rafia et al, 2008). These developing countries face the challenge of rapidly increasing waste volumes beyond what their current infrastructural and organizational, institutional and financial arrangements can cope with. The investment requirements for the physical infrastructure and capacity building to properly collect, segregate and recycle waste materials are substantial (Felix Busse, 2012). A typical solid waste management system in a developing country displays an array of such problems as low collection coverage and irregular collection services, crude open dumping and burning without air and water control, the breeding of flies and vermin, and the handling and control of informal waste picking and scavenging activities (Hisashi, 2012). This statement of fact holds true in Nigeria where these problems emanating from poor solid waste management has become a debilitating factor towards sustainable development.

Anambra is a states in south-eastern Nigeria. It is located at 6°20′N 7°00′E and consists of twenty one local government areas contained within a total land area of 4,844 km^2 (Wikipedia, 2012). The state is nicknamed "*Light of the Nation*", meaning "*Ife Mbà"* in Igbo language. Going by the 2006 population census in Nigeria, Anambra State has a population of 4,177,828 people (NPC, Awka, 2014) with a density of 840/km^2, ranking tenth (10th) among the thirty six (36) states of the Nigerian federation. Total GDP of the state in 2007 was $11.83 billion, with a per capita of $1,615 (Adichie C., 2008). The capital city of Anambra State is Awka. Anambra State as the "Light of the Nation (Nigeria)" is not exempted from the problems of SWM. To enable the state tackle these problems, it has set up several agencies to manage solid waste generated within its major cities. The Agency presently in charge of managing waste in the state is the ASWAMA. ASWAMA succeeded ANSEPA in 2011.

3. Materials and Methods

Data were obtained from both primary and secondary sources by means of questionnaire and literature reviewed. The questionnaire were administered to a total of two hundred workers of the solid waste managers (ASWAMA and Laga International Nig. Ltd.) in Anambra State. Agents who assisted in the research had writing and protective materials as part of their tools kit and were permitted to take photographs and/or video recordings where necessary. Some of the secondary data sources used in the study include: textbooks, journal articles, newsletters, official reports, and the internet. Official reports referred to here include reports from private and government recognized institutions like the ASWAMA, local government area authorities, ministry of information and NPC in the state, government recognized private contractors, NGOs, CBOs, the internet, et cetera. Descriptive statistics was used in analyzing the information obtained in an excel spreadsheet. Techniques employed include SWOT, causal loop and Fishikawa analyses, hypotheses testing, and the Pareto Principle.

Meanwhile, to check if a sample size is scientifically acceptable to represent the population of a known system, we use the Yaro Yamen's model given by the relation:

$$\mathbf{n} = \frac{N}{1 + Ne^2} \quad (1)$$

Whereas the a Chi square value is determined from the equation,

$$x^2 = \sum[\frac{(f_o - f_e)^2}{f_e}] \quad (2)$$

Where,

$$f_e = \frac{(TR \times TC)}{GT} \quad (2a)$$

$$df = (R - 1)(C - 1) \quad (2b)$$

4. Results and Discussion

Out of the 200 copies of questionnaire administered to the waste management workers, only one hundred and thirty (135) copies were filled and returned. This number was taken as the sample population for the study.

4. 1 Investigation into the Capabilities of ASWAMA - a SWOT Analysis

ASWAMA is a legal entity formed by the Anambra State government. Its capabilities and activities in delivering its primary duty to the state were investigated using both SWOT and causal loop analyses. The results are shown in Table 1 and Figure 1

Table 1: Performed SWOT analysis on ASWAMA

STRENGTHS	**WEAKNESSES**
Established and backed by law Has day-to-day direct contact with waste producers/generators Charges some token over waste producers Receives annual subvention from government Awareness raising potential Availability over a range of vehicles	Political influence Capacity gaps and shortfalls Priority conflict Implementation of imposed policies (the effects are pronounced) Performance level still low Creation of public awareness campaign still very low Partial or no understanding of real own emissions and external costs No proper method for measuring actual quantities of waste generated/evacuated No practice of 3R principle.
OPPORTUNITIES	**THREATS**
Funding schemes (state govt., EU, private sector, etc) Public Private Partnership (anids) Clustering/grouping PAYT "mix"	PAYT failure, leading to increased littering Existence of private waste managing contractors High costs of collection and disposal Lack of recycling plants No means of leachate recovery Global warming Fire outbreak at dump sites Outbreak of a disease(s)

4.2 Causal Loop Analysis of ASWAMA And Private Waste Managers' Capabilities in Managing Solid Waste in Anambra State

Figure 1 indicates that when ASWAMA receives its budgetary allocation from the state government, it is empowered and motivated to go into waste collection and disposal activities in the capacity of the available resources. The state government, therefore, expects that before it gives the next budgetary allocation to ASWAMA, the latter should ensure that the previous allocation was judiciously utilized for maximum benefits.

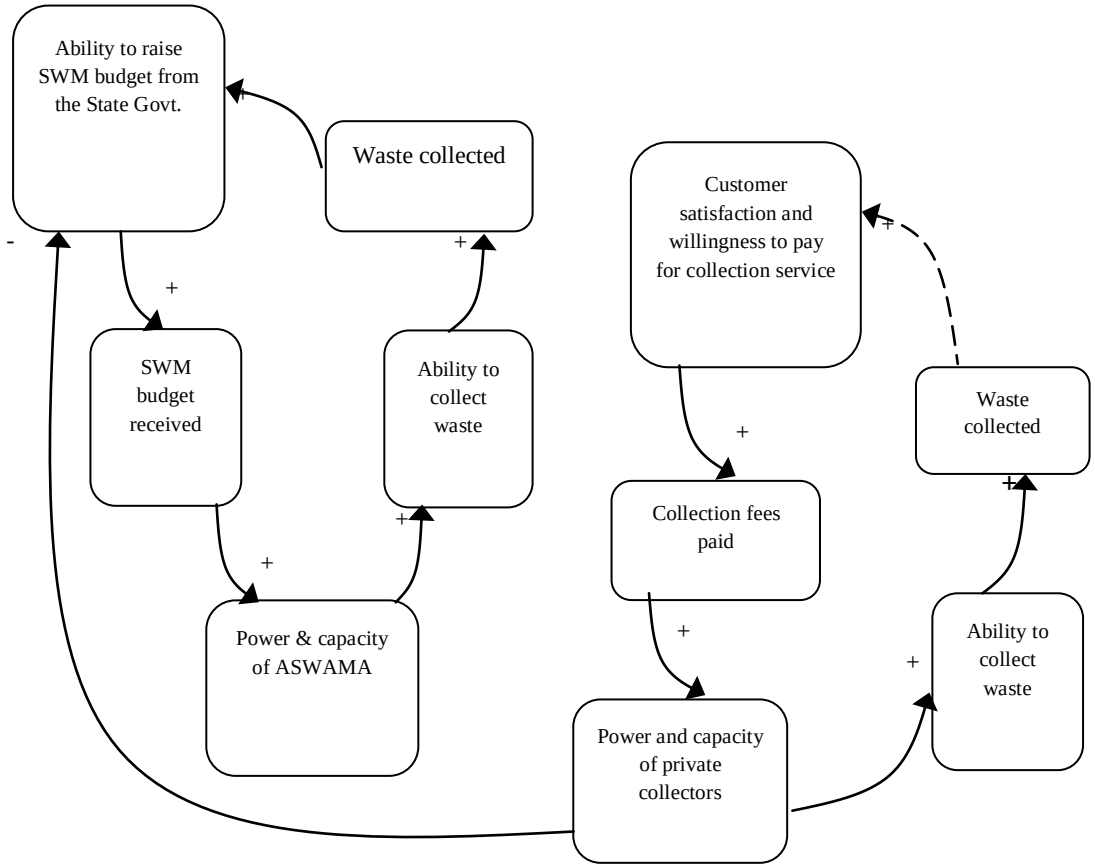

Figure 1: A Causal Loop Diagram showing the requirements/processes that improves the capabilities of waste managers in Anambra State [Adapted from Kasozi and Blottnitz, 2010]

On the part of private waste collectors, when the customers pay for waste collection services they expect quality and effective service to be delivered. When they are satisfied with the previous services, they will be willing to pay for the next collection services. Anambra State government does not consider or give budgetary allocation to private waste collectors and as such, when their customers make payments for disposal of their waste the private collectors are further encouraged and motivated to render the services within the limits of the available resources.

4.3 Factors Constraining Development of Effective SWM System in Nigeria

Many factors have been identified as the constraints in developing an effective solid waste management system in Nigeria. These factors bring about public health, environmental and management problems. Ezigbo (2012) identified some of the factors as high rate of growth in urban population coupled with increased commercial and industrial activities which result to phenomenal increase in the volume and diversity of solid waste being generated; lack of adequate physical planning, functional drainage system, proper housing condition, and environmental pollution which result from high industrial activities; poorly planned road network and lack of adequate parking space resulting in perpetual traffic congestion. Adeshina (2000) added to these factors, inadequate public toilets and sewage systems. In their findings, Chukwuemeka et al (2012) reported that the resources normally voted by government annually for managing was very small and there was no adequate environmental education; that some of the waste management staff were poorly trained with no plan in future to give them further training or to improve their already acquired skills. They also saw non-participation of local communities in SWM and non-inclusion of detailed topics on SWM in primary, secondary and tertiary institutions as constituting part of the problems. Ogwueleka (2009), in his own report pointed at inefficient collection methods, insufficient coverage of the SWM collection system, improper disposal of solid wastes, lack of institutional arrangement, insufficient financial resources, absence of by-laws and standards on SWM, inflexible work schedules, insufficient information on quantity and composition of waste and inappropriate technology as being the major causes of poor solid waste management in Nigeria.

Besides, Olorunfemi and Odiata (1998) also reported that lack of data on solid wastes in Nigeria, which is at all levels (from wards, through the local government areas/districts/urban centers, the state to the federal) has remained the most conspicuous and probably, the most important problem militating against the successful and effective management of solid wastes by their respective waste management authorities. Even where such data exist, they are generally unreliable, scattered and unorganized (World Bank, 2003).

Meanwhile, the above mentioned constraints have been summarized and categorized into six major groups as represented in the Fishbone diagram of Figure 2

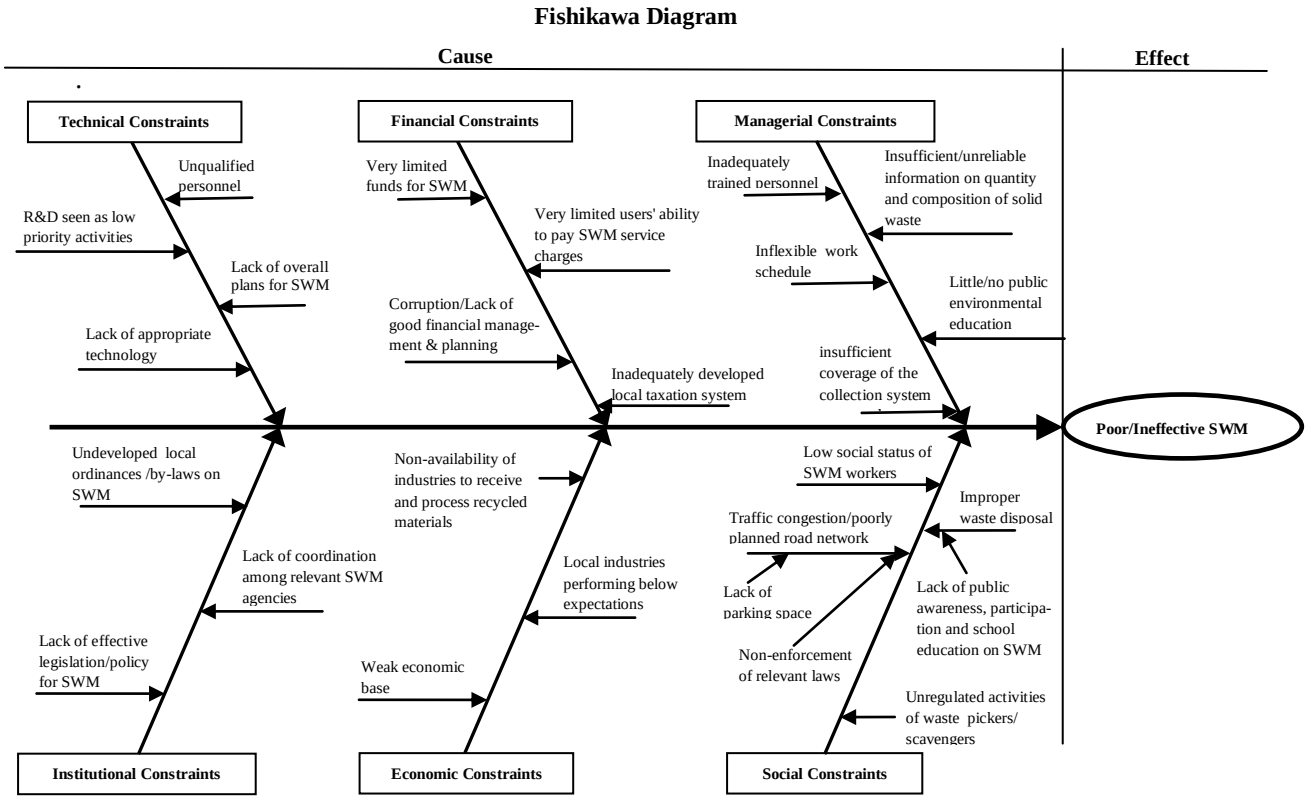

Figure 2: Causes of poor/ineffective solid waste management

4.4 Constraints in ASWAMA's Efforts to Providing Effective SWM

Responses given by the Anambra State solid waste management workers to the questionnaire shared to them show that the major factors which cause poor or ineffective and inefficient solid waste management in Anambra State can be summarized in six folds: 1. The overhead costs of managing solid waste in an effective, efficient and sustainable manner is high; 2. No proper method for data management of the waste produced in the state exist; 3. Standard tools for evaluating past performances, scheduling for waste evacuation, and forecasting future productions of these waste so as to enable proactive management measures to be taken are lacking; 4. inability (or lack of means) to acquire the needed technology to convert the generated waste into wealth. 5. No clear cut policy on solid waste management exist in the state 6. Other factors such as absence of waste reprocessing/recycling plants, poorly planned road network resulting in perpetual traffic congestion, lack of adequate physical planning, functional drainage systems, proper housing condition, high industrial activities, et cetera.

Table 2 depicts the various classes of waste management workers to whom the questionnaire were shared. Out of the 200 copies of the questionnaire distributed, only 135 were filled and returned. Now, having presented the above data,

Table 2: Distribution of the questionnaire to waste management workers [Source: Field survey]

Category By Rank	Estimated Size of Population	Number Of Questionnaires Issued	Number Of Questionnaires Filled & Returned	No. Of Years Of Work Experience		
				Below 3 Yrs	3 – 6 Yrs	Above 6 Yrs
TLM	19	19	10	0	2	8
LLM	38	38	22	0	10	12
OSC	143	143	103	39	30	34
Total:	***200***	***200***	***135***	***39***	***42***	***54***

what is left for one to do next is to check if the sample size of 135 workers is scientifically acceptable to represent the targeted population of 200 solid waste workers. This is verified by the use of Yaro Yamen's formula, eqn. (1). After the calculation, a sample size of 133 workers was obtained. This number obtained is less than the sample size of 135 workers in Table 2. Consequently, the sample size of 135 workers is scientifically acceptable as our sample size..

On the question, "What are the reasons for ASWAMA's inefficient solid waste management in the state?" which led to the responses in Table 3, the workers were given the privilege of marking as many of the options as they considered appropriate, however, none should be marked or selected more than once. After collation and little statistics, it was discovered that a total of 219 (43.75%) of the respondents considered insufficient funding as the major reason why ASWAMA was performing below expectation. 106 respondents (21.25%) indicated that standard tools for evaluating past performances, scheduling for waste evacuation, and for forecasting future productions of the waste so as to enable proactive management measures to be taken was the main cause; whereas 56 (11.25%) of the respondents claimed that inability (or lack of means) to acquire the needed technology to convert the generated waste into wealth was the major cause of their inability to perform as expected. 44 (21.28%) respondents said that the major cause was non-existence of proper method for data management of the waste produced in the state; In their own opinion, 31 respondents (about 6.25%) insisted that the major cause of their poor performance was non-existence of clear-cut policy on solid waste management in the state; whereas 19 respondents (about 3.75%) pointed at corruption as the major cause of the problem

in question; and 25 respondents (about 5.00%) were convinced that some other reasons not included in the options could be among the major causes. This information is contained in Table 3 and depicted in Figure 3.

Table 3: Waste management workers' views on the causes of ASWAMA's poor performances

Enquiry Index	No. of Respondents	% Representation
Insufficient funding	219	43.75
Non-availability of vital tools	106	21.25
Lack of modern technology	56	11.25
Poor data management	44	8.75
No clear-cut policy on SWM	31	6.25
Corruption	19	3.75
Others factors	25	5.00
Total =	***501***	***100.00%***

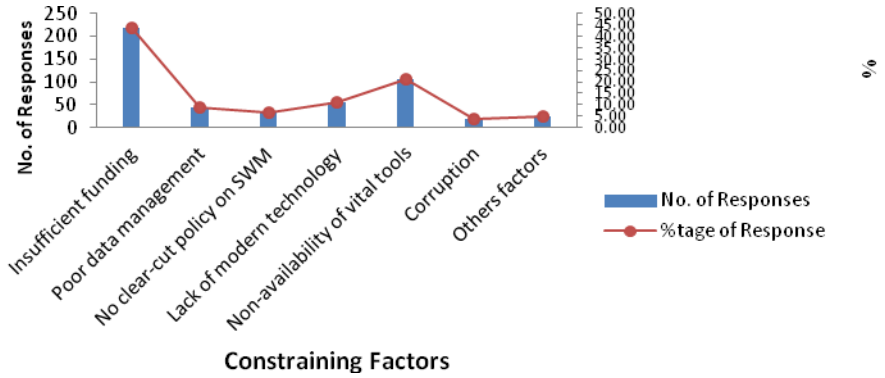

Figure 3: Waste management workers' views on the causes of ASWAMA's poor

4.5 Application of Pareto (80:20) Principle

From the foregoing detailed discussions, it is seen that many factors militate against the Anambra State solid waste managers performances in the state. However, existence of the Pareto law reminds us that among these lot there are still few critical ones. As such, the Pareto (80:20) Principle is used in this section to identify these most nagging few among the many number of ASWAMA constraints. The analysis is done Table 4 and depicted in Figure 4.

Table 4: The Respondents' views on the causes of poor solid waste management in Anambra State

Enquiry Index	No. of Responses	% Responses	Cumulative No. of Responses	Cumulative %
Insufficient funding	219	43.75	219	43.75
Non-availability of vital tools	106	21.25	325	65.00
Lack of modern technology	56	11.25	382	76.25
Poor data management	44	8.75	426	85.00
No clear-cut policy on SWM	31	6.25	457	91.25
Corruption	19	3.75	476	95.00
Others factors	25	5.00	501	100.00

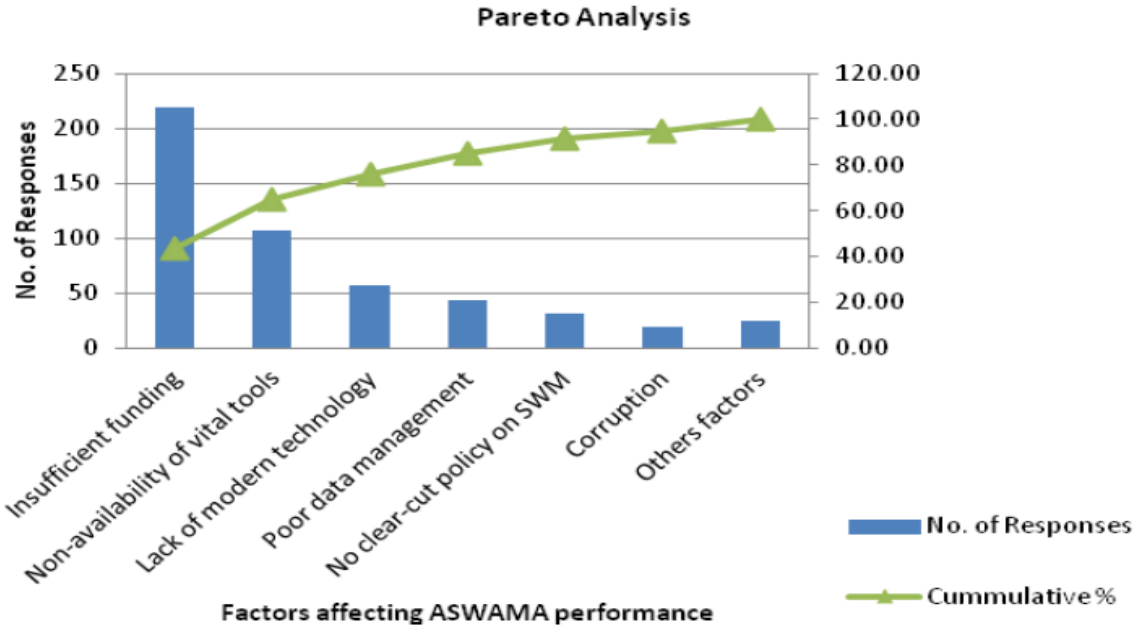

Figure 4: Result of the Pareto analysis

Data in Table 4 and Figure 4 clearly show that inadequate funding constitutes nearly 44% of the reasons why ASWAMA is performing below expectation in its SWM service delivery; while poor data management assumes about 8.75% of the causes. By implication of the results obtained from the analysis, therefore, provision of adequate funding, necessary tools and equipment, use of modern technology and proper data (information) management will eliminate about 85% of the factors causing the low productivity/performance in ASWAMA. The results also suggests that poor data management (or lack of data) is not "... the most conspicuous and probably, the most important problem militating against the successful and effective management of solid wastes by..." ASWAMA as identified by Olorunfemi and Odiata (1998)

4.6 Tests of the Research Hypotheses

A very nagging issue in solid management is funding the project. Enquiries made showed that Anambra State earmarked the sum of seven million naira (N7 m) as budgetary allocation it gives to ASWAMA for SWM in Awka city. The enquiries also enabled the following hypotheses to be drawn:

Ho: The amount of money released as budgetary allocation to ASWAMA is enough for the Agency to achieve its objective functions.

H1: The amount of fund released as budgetary allocation to ASWAMA is not enough for the Agency to achieve its objective functions.

Solution

The respondents were required to mark only one of the provided four options for this question (see Table 5), double entries is rejected.

Table 5: Sample evidence for the research hypothesis

Research Question	Response	No. of Years Of Work Experience			Group Total	%tage of Group In Sample Size
		Below 3 yrs	3 - 6 yrs	Above 6 yrs		
To what extent is the ₦ 7m budgetary allocation released to ASWAMA appropriate for achieving the objectives of the Agency?	To a very large extent	5	3	0	8	5.93
	To a large extent	17	13	11	41	30.37
	To a little extent	10	21	27	58	42.96
	To no extent	4	10	14	28	20.74
	Total:	36	47	52	135	100.00

The expected number of workers that were in favor of or against the view that the amount of money released to ASWAMA is appropriate for achieving the company's objectives was calculated using eqns. (2)-(2b), Tables 6 and 7.

Table 6: Expected frequency

2.13	2.79	3.08	8.00
10.93	14.27	15.79	41.00
15.47	20.19	22.34	58.00
7.47	9.75	10.79	28.00
36.00	47.00	52.00	135.00

Table 7: Calculation of the x^2 values

f_o	f_e	$(f_o - f_e)^2$	$\frac{(f_o - f_e)^2}{f_e}$
5	2.13	8.218	3.852
3	2.79	0.046	0.017
0	3.08	9.496	3.081
17	10.93	36.804	3.366
13	14.27	1.623	0.114
11	15.79	22.969	1.454
10	15.47	29.884	1.932
21	20.19	0.652	0.032
27	22.34	21.709	0.972
4	7.47	12.018	1.610
10	9.75	0.063	0.007
14	10.79	10.335	0.958
		$\sum[\frac{(f_o - f_e)^2}{f_e}] =$	17.395

refers, as $f_{e11} = 2.13$; $f_{e12} = 2.79$; $f_{e13} = 3.08$; $f_{e21} = 10.93$; $f_{e22} = 14.27$ and $f_{e23} = 15.79$. By the same token, $f_{e31} = 15.47$; $f_{e32} = 20.19$; $f_{e33} = 22.34$; $f_{e41} = 7.47$, $f_{e42} = 9.75$ and $f_{e43} = 10.79$. Where the subscripts 11, 12, 13,…,43 refer to total values in cells of (row1, column1), (row1, column2), … (row4,column3). The Chi-square value $x^2 = 17.395$ in Table 7 and the standard Chi-square table value for d$f = 6$, $x^2_{0.05} = 12.5916$ show vividly that the calculated value of x^2 (17.395) is higher than the table value of 12.5916; implying that the research hypothesis does not hold good, therefore, we conclude that the amount of money released to ASWAMA as budgetary allocation is not appropriate for the Agency to achieve its objective functions.

5. Conclusion

In conclusion, numerous factors hinder the efforts of solid waste managers in providing effective, efficient and sustainable solid waste management services in their localities. Four out of all these constraints namely, insufficient funding, non-availability of vital tools/equipment, lack of modern technology and lack of data/improper data management - have been identified, verified and validated through a case study as being the dominants in Anambra State solid waste management system. Adequately eliminating these four constraints will reduce their effects in the state by about 85%; ASWAMA will be enabled to provide effective and efficient services to the state. Besides, the hypotheses drawn on the questionnaire confirmed funding as a serious factor for consideration in Anambra State SWM. Analysis made showed that the amount of money presently issued to ASWAMA as annual budgetary allocation is not sufficient for the Agency to achieve its legal objectives. By implication, therefore, Anambra State government should set the

necessary machineries in motion to continuously monitor, evaluate and adequately sponsor ASWAMA for quality service provision, sustainability and continuous improvement.

References

Chukwuemeka, Emma E. O.; Osisioma, B. C.; Onwuka, Ebele; Ugwu, Joy (2012). *The challenges of waste management to Nigeria sustainable development: A study of Enugu State*. International Journal of Research Studies in Management 2012 October, Volume 1 Number 2, 79-87

Ihueze C. C. and Chukwumuanya E. O. (2015). *Cost Estimation and Waste Production Forecast Models for Sustainable Solid Waste Management: A Study on Anambra State Waste Management System*. International Journal of Applied Sciences & Engineering, 3(1): 14-18. www.ijapscengr.com

Rafia Afroz, Keisuke Hanaki and Kiyo. H. Kurisu (2008). *Factors Affecting Waste Generation and Willingness to Recycle: a Study in a Waste Management Program in Dhaka city, Bangladesh*. Faculty of Economics and Business (FEB), University of Malaysia Sarawak (UNIMAS). (FEB Working Paper Series No. 0803

Felix Busse (2012). Financing waste projects, a challenging opportunity. Private Sector & Development

T. Ch. Ogwueleka (2009). *Municipal solid waste characteristics and management in Nigeria*. Iran Journal of Environmental Health Science and Engineering, 2009, Vol. 6, No. 3, pp. 173-180

Olorunfemi J.F, Odiata C.O (1998). *Land use and solid waste generation in Ilorin, Kwara State*. The Environmentalists. 2: 67-75.

UNICEF (2006). *Solid and Liquid Waste Management in Rural areas*. A Technical Note, 2006.

World Bank, (1992). *World Development Report, Development and Environment*, New York. Paper No 13

Agunwamba, J.C., Egbuniwe, N., Ogwueleka, T.C., (2003). *Least cost management of solid waste collection*. Journal of Solid Waste Technology and Management, **29** (3): 154-167.

Cointream, S. J., (1982). *Environmental management of urban solid waste in developing countries: a project guide*. Urban Development Technical paper No 5. The World Bank, Washington, DC. June

Wikipedia, the free encyclopedia (2012). *Anambra State*

Pryor Fred (2015). *Excel Tips and Tricks*. Microsoft® Excel® experts at Fred Pryor Seminars and CareerTrack, division of PARK university Enterprise, Inc.

Wikipedia, the free encyclopedia (2015). *Pareto distribution.*

Wikipedia, the free encyclopedia (2015).. *Pareto chart.*

Nancy R. T. (2005). *The Quality Toolbox*, Second Edition, ASQ Quality Press, 2005, pp. 376-378

Pareto Chart in Excel - Easy Excel Tutorial on the net.WWW.EXCEL-EASY.COM