Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 3, No.7, 2013

Application of an Integrative Approach for Municipal Solid Waste Management Assessment: Towards Adopting a Conceptual Model for Efficient and Sustainable Solid Waste Management

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Abstract
Solid waste management is a global issue that is a growing source of concern in develop and developing countries due to increasing urbanization, changes in consumer pattern and industrialization, which all directly influence solid waste generation. Solid waste is fast becoming an environmental hazard with its management overwhelming the capabilities of the local authorities, which in most countries are responsible for solid waste management. Solid waste management systems vary in most countries with factor that influence each system, as a result different countries adopt different systems with assessments and modifications to suit. This paper assesses solid waste management in FCT Abuja and Putrajaya in a comparative and correlative approach towards adopting a model to suit FCT Abuja with the aim of improving solid waste management in the state.
Keywords: Solid, Waste, Management, System

1.0 Introduction

Presently the rapid population increase due to urbanization in FCT Abuja metropolitan area and outside the metropolis have caused difficulties for the state and local environmental protection agencies in providing an effective and efficient municipal solid waste management system (Olanrewaju and Ilemobade, 2009; Zamorano *et al*., 2009). Urbanization generally affects landuse and when not controlled causes the emergence of illegal structure and neighbourhoods which is characteristic of some areas within and outside the metropolis. This has ultimately affected the city plan, thereby affecting services such as; waste collection, eventually leading to illegal dumping. The management of municipal solid waste has become a major environmental problem, especially for fast growing cities like the current federal capital; FCT Abuja, with generation amount increasing yearly. Illegal dumps in the middle of residential areas have become common, with odours and rodent. These open dumps cause health risks and reduce the aesthetic value of the surrounding environment, detoriation of the urban environment, as well as contaminate natural resource (Ogu, 2000). The rapid growing waste generation rates and high cost of waste disposal, depletion of landfill space and the problem of obtaining new disposal sites thereby resulting in open dumping are unresolved issues. This makes it difficult for waste management authorities to identify and create solutions (Gomez *et al*., 2009). Even though several policies and programmes have been put in place to manage municipal solid waste, they prove ineffective due to financial and human constraints (Abuja-Citiserve, 2004). The objective of this research paper is to assess the municipal solid waste management in both cities, towards adopting a conceptual model for efficient and sustainable solid waste management in FCT Abuja municipal area.

2.0 Literature Review

Tanskanen (2000) developed and applied a computer model to study the integrated municipal solid waste management in Helsinki metropolitan area (Finland). The model was developed for analyzing on-site collection systems of waste materials separated at the source. The study aimed at finding and analyzing separation strategies, fulfilling the recovery rate targets adopted for municipal solid waste in Finland. Chang and Davila (2008) offered a unique municipal solid waste investigation with regard to both physical and chemical characteristics illuminating the necessary management policies with greater regional relevancy. Zotos *et al*., (2009) developed a systematic approach for municipal solid waste management at both the household and non-household level. It aimed at providing a framework in the municipal solid waste management field for municipalities in Greece, as well as other countries facing similar problems. Turan *et al*. (2009) presented a brief history of the legislative trends in turkey for municipal solid waste management; the study presented the municipal solid waste responsibilities and management structure, together with the present situation of generation, composition, recycling and treatment. Bovea *et al*. (2010) compared from an environmental point of view different alternatives for the management of municipal solid waste generation in a town within Spain. Tunesi in (2010) analyzed local waste management strategic and management planning documents. In the paper three different emerging energy recovery strategies where identified, with each energy recovery strategy

resulting in different solutions in terms of technology selection. Ahiamadu (2007) carried out a comparative analysis on various waste management options, with emphasis on the health and environmental impacts of municipal solid waste and the challenges confronting municipal solid waste management in Nigeria. Olanrewaju and Ilemobade (2009) researched on Ondo state integrated waste recycling and treatment project in Nigeria, looking into the issue in terms of municipal solid waste management before and after the introduction of this system. They documented the success of the project in turning waste to wealth. Babayemi and Dauda (2009) evaluated the solid waste generation, categories and disposal option in developing countries. They used Nigeria as a case study; their study results indicated large generation at high rates without corresponding efficient technology to manage the waste. Onwughara *et al*. (2010) studied the issues of road side disposal habit of municipal solid waste in Nigeria. The paper emphasized on various waste management options; integrated waste management, environmental impacts under health, social effects and the legislation of extended producer responsibility were suggested.

Several studies over the years have been carried out towards addressing these issues, different methods have been applied toward resolving different aspect of solid waste and waste management issues as a whole. Currently there is an increasing popularity of the system analysis techniques in the assessment and management of solid waste, specifically the system assessment models. This requires less time, effort, raw data, and variety of application. It is flexible and can be used integratively with other decision tools. This study looks into municipal solid waste management in the Federal Capital territory of Nigeria; FCT Abuja using integrated solid waste management system (ISWMS) as an assessment tool. This ensures that all system components which comprise of solid waste management are incorporated into the investigation. This study was conducted using two case studies; FCT Abuja and Putrajaya. Putrajaya will be used as a reference for comparison due to the similar criteria both cities share.

3.0 Methodology

Integrative Framework for MSWM Assessment

Assessment is the process of documenting, usually in measurable terms, knowledge, skills, attitudes and beliefs. This can be subjective or objective and an informal assessment usually occurs in a more casual manner. This may include observation, inventories, checklists, rating scales, performance and portfolio assessments, participation, peer and self -evaluation, and discussion. Tools used in assessment can consist of manuals, guidelines, software's, models and surveys.

When selecting an assessment method, the selection should: answer questions that are important, time efficient, cost available and resources effective. Results should give useful feedbacks that highlights efficiencies and identifies areas that are deficient. When selecting an assessment tools/ methods, selection should be based on the tools/methods that will provide the most useful and relevant information for the purposes. Many outcomes will be difficult to assess using only one measure so an integration of two or more methods is recommended (University of Massachusetts Amherst, 2001). The advantages to using more than one method include:

1. Multiple measures can assess different components of a complex task
   No need to try to design a complicated all-purpose method
2. Greater accuracy and authority achieved when several methods of assessment produce similar findings
3. Provides opportunity to pursue further inquiry when methods contradict each other.

All assessment measures do not have to involve quantitative measurement. A combination of qualitative and quantitative methods can offer the most effective way to assess goals and outcomes. Effective methods of assessment provide both positive and negative feedback (University of Massachusetts Amherst, 2001).

ISWM as an Assessment Tool

ISWM provides a set of tools for managing the waste problems in cities (UNEP, 2009a). It's a framework for understanding the problems and finding solutions. Which is very crucial due to the collapse of many SWMS is related to an inadequate analysis of the problem (UNEP, 2009a). The integrated solid waste management (ISWM) concept as a whole is based on experiences, there is no standardized methodology (Klundert and Anschutz, 2001). ISWM recognises three important dimensions in waste management;

1. Stakeholder; residents, local authorities, politicians, scavengers, NGOs, partners and manufacturers. Each stakeholder has various interest and role in waste management.
2. Waste system elements; generation, storage & separation, collection, transfer & transport, processing & transformation and disposal
3. Sustainability; waste reduction, reuse, recycling and recovery (waste hierarchy)

Integrated solid waste management can be used as an assessment/analysis tool for critical assessment (Klundert and Anschutz, 2001). The concept involves technical, financial-economic, sustainability, socio-cultural, environmental, institutional and political aspects. Which influence the overall sustainability of waste management, This was chosen as the assessment tool for this research due to the characteristic of the model;

strategic and long term approach, holistic, detailed and wide applicability with respect to components. Due to financial and time constraint not all components of the ISWM model will be used for study; only components that will enable fulfillment to the set objective. Mannapperuma and Basnayake (2009) carried out a detailed SWOT Analysis for the waste management authority (WMA) of the western province of Sri Lanka, towards studying the present scenario of the waste management system. A comprehensive waste management strategy was identified to address most of the identified problems.This research is descriptive using survey method, the questionnaires were adopted from UNEP, 2009b, WHO, 1996 and previous studies. They consist of questions and components needed to properly assess a MSWMS from the residents and administrative/institutional perspective with component identified by ISWMS for system waste management assessment. The analysis used involved comparative and correlative approaches. The residential questionnaires were distributed randomly to 400 respondents in each city; calculated from the formula below. The administrative questionnaires were distributed using purposive sampling.

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

Source: (Krejcie and Morgan, 1970; Fox *et al.,* 2009)

Where: n =the sample size, N =the population size; 1,406,239 for FCT Abuja (NPC, 2012) and 72,413 (DOS, 2012), e =the level of precision.

For FCT Abuja:

$$n = \frac{1{,}406{,}239}{1 + 1{,}406{,}239(0.05)^2}$$

$$n = \frac{1{,}406{,}239}{3{,}516.5975}$$

$$n = 399.89$$

For Putrajaya:

$$n = \frac{72{,}413}{1 + 72{,}413(e)^2}$$

$$n = \frac{72{,}413}{182{,}0325}$$

$$n = 397.80$$

4.0 Results/Discussions

4.1 Demographic Assessment

Gender

In FCT Abuja 55.4% of the population comprises of males and 45.6% females, while in Putrajaya 53.8% comprises of males and 46.2% females. Totally there are 54.1% males and 45.9% females in both cities combine as shown in Figure 1. Mann-Whitney U test is carried out to determine if there is a significant difference in the gender distribution when both cities are compared. The results obtained gave a Z value of -0.174 with p=0.862. Therefore it can be concluded there is no significant difference statistically in the gender category distribution when both cities are compared at a 95% confidence level (CL).

Occupation

In FCT Abuja 59.8% of the population consist of government workers and 40.2% nongovernment workers, while in Putrajaya 40.7% of the population consist of government workers and 59.3% non-government workers as shown in Figure 2. When both cities are compared with regards to the distribution based on occupation, using Mann-Whitney U test a Z value of -5.472 is obtained with p=0.001. It can therefore be concluded the occupation category distribution of the respondents in both cities is significantly different statistically at a 95% CL.

Age Group Distribution

In terms of age group it can be seen from Figure 3, Putrajaya has a higher percentage for ages 16-26 at 49.3% compared to FCT Abuja with 12.4%. In other age categories FCT Abuja has a higher percentage of distribution. On further analysis to compare both cities using the Mann-Whitney U test a Z value of -12.135 is obtained with p=0.001. Therefore it can be concluded with regards to age group distribution both cities are significantly different statistically at a 95% CL.

Number of Individual per Household

From Figure 4 it can be seen that FCT Abuja has the highest percentage of individual per household sheltering 9 people and above at 9.8% compared to Putrajaya which has 0.6%. In Putrajaya 2-5 individuals per household is higher than in FCT Abuja. On further analysis to compare both cities using the Mann-Whitney U test a Z value of -6.359 is obtained with a p=0.001 (Table 7 Appendix 2). It can therefore be concluded that the distribution of the number of individual per household differs significantly when both cities are compared statistically at 95%

CL.

Level of Education

In FCT Abuja there is a higher percentage of individual with no education at 2.9%, while in Putrajaya 0.5%. Putrajaya has a higher percentage of individuals with secondary education at 19.9% with FCT Abuja having only 9.1%. FCT Abuja has a higher percentage of individual with university education at 67.5%, while Putrajaya has 49.1% as shown in Figure 5. On further analysis using the Mann-Whitney U test to compare both cities, a Z value of -4.923 is obtained with p=0.001. It can be concluded there is a significant difference in the educational level distribution in both cities statistically at a 95% CL.

Total Family Income

In FCT Abuja the majority of respondents total family income is between 100,001 Naira and above; 30.4%, while 8.5% of respondents have a total family income of 20,000 Naira and below as shown in Figure 6. In Putrajaya the majority of the respondents; 27.9% have a total family income of 2,001-3,000 RM as shown in Figure 7, while 6.2% of the respondents have a total family income of RM 5,001 and above.

4.2 Status of Solid Waste Management in FCT Abuja and Putrajaya

AEPB is the state department in charge of environmental issue and its management, which solid waste management is inclusive but under the federal law waste management is one of the responsibilities of the areas councils. This is an overlap that has affected waste management on many levels in FCT Abuja. AEPB consist of about 8 department, public relations, accounts & finance, environmental health, administrations & supplies, enforcement & monitoring, environmental monitoring, planning, research & statistics, environmental conservation, waste management and sanitation department; inclusive consisting of units such as solid waste, clinical waste and liquid waste. The solid waste, clinical waste and liquid waste management are the responsibility for the waste management and sanitation department. AEPB has contracted waste collection and transfer to 20 contractors, which carry out door-door collection for the residential areas, collection point evacuation for commercial area and institutions within the federal capital city (FCC). The FCC has three landfill, of which only two are currently operational under the management of abuja environmental protection board (AEPB); Mpape dumpsite, Gosa dumpsite and Ajata dumpsite. Currently only Gosa and Ajata dumpsite are operational. These dumpsites are under the management of AEPB, but five other area councils have their own dumpsites (FCT Abuja has six area councils; Gwagwalada, Bwari, Kwali, Kuje, Abaji anf AMAC).

In Malaysia, the Federal cabinet as early as 6 September 1995 has decided that the responsibilities of the local authorities in area of municipal solid waste management should be privatized. As a precondition to total privatization, the federal cabinet again in 1998 decided that the privatization of solid waste management for the country to be carried on interim basis. Since 1 January 1997, the solid waste management responsibility of 48 local authorities was privatized to 3 concession companies; Idaman Bersih Sdn Bhd for norther region, Alam Flora for the central region and Southern Waste for the southern region (Manaf *et al*., 2009). As at April 2007 there were 291 landfill sites all over the country and about 112 of these sites were not in operation and 179 are still operating (10 sanitary). As part of the Malaysian governments vision 2020 agenda includes the ungraded of open dump landfills to sanitary landfills (Eusuf *et al*., 2007). Waste from Putrajaya was transported initially to Air Hitam at Puchong from 1995-2005, Dengkil inert waste landfill from 2004-2007, Tg. Dua Belas sanitary landfill from 2007-date and Refuse-Derived Fuel plant in Kajang at present. Alam Flora Sdn. Bhd. (AFSB) is the leading provider of integrated solid waste management solutions in Malaysia. Alam Flora Sdn. Bhd. was awarded solid waste management concession in December 1995. Their service area covering the Federal Territory of Kuala Lumpur, states of Selangor, Pahang, Terengganu and Kelantan (including Putrajaya). Putrajaya waste quantities are not high so waste is not sent to any transfer station; after collection it is sent directly to the landfill with exception to waste that has been segregated at source. Segregated waste is sent to the RDF center at Semiang Kajang. At the landfill there is no recovery; Tg. Dua Belas but there are a few scavengers. The management of the landfill is under ministry of housing and local government but operated by Worldwide Holdings Berhad (WHB), they operates another sanitary landfill in Tanjung Dua Belas, Kuala Langat. Putrajaya currently does not have its own transfer station but there are plans for the construction of a recovery center, for waste that will be landfilled, incinerated or processed for recyclable items.

In Abuja Municipal area waste composition is heterogeneous and mixed; non-degradable materials and degradable components. The waste is not segregated at the source and comprises of hazardous and non-hazardous waste. The hazardous components usually consist of house hold cleaning agent and left over chemical from renovations. In Abuja waste bulk mainly consist of plastics, paper, glass, metal and other recyclable components. The degradable portions of the waste consist of food waste and yard waste (Kadafa *et al.,* 2012). From the survey analysis, in FCT Abuja 80% of the respondents have open dumps within their neighbourhood while in Putrajaya 25.5% of the respondents have open dumps in their neighbourhood as shown in Figure 8. Further analysis is carried out to compare both cities based on the sighting of open dumps within areas of resident. Mann-Whitney U test is used p=0.001, as shown in Table 1. Therefore it can be concluded by 95% CL

there is a statistical significant difference when both cities are compared. In areas where waste collection is provided by AEPB collections are irregular as shown in Figure 9. Figure 9 consist of the frequency of waste collection for FCT Abuja and Putrajaya, daily collections is 10.3% in FCT Abuja while in Putrajaya 52.9%, once weekly collections is 45.1% in FCT Abuja and 8.9% in Putrajaya, several times weekly collections is 7.8% in FCT Abuja and 21.6% in Putrajaya and collections at longer intervals is 15.9% in FCT Abuja and 0.3% in Putrajaya.

The pattern of collection based on frequency where in FCT Abuja there are mostly once and twice weekly collections of waste, while Putrajaya has mostly daily waste collections. On comparison of both cities based on the frequency of waste collection using Chi-square test as shown in Table 2, p=0.001. It can be concluded there is a statistically significant relationship in the frequency of waste collection in both cities by a 95% CL; in other words a significant difference between city and waste collection frequency. Recycling and reduction are waste minimization practices in the 3-R hierarchy system, which form the backbone of most waste management systems. In FCT Abuja the percentage of the respondents that practice waste reduction is at 22.7% and Putrajaya 32.3%, while recycling is 17% in FCT Abuja and 78.4% in Putrajaya.

4.2 Adopting a Conceptual Model for Effective and Sustainable Waste Management in FCT Abuja

The major problems that generally affect the efficiency and sustainability of a SWMS based on the administrative assessment are clustered into groups, each cluster represents a dimension as shown in Table 3 and totally there are four dimensions. The scale of the dimensions is found to be reliable based on the results of the reliability test for each dimension and the total dimension, as shown in Table 4. The results of the normality test shows the dimensions are normally distributed based on the results of the Q-Q, box plot graphs and further supported by the results of One-Sample Kolmogorov-smirnov test. Based on the correlation results; which shows which dimensions are closely correlation; improvement in one dimension will lead to improvement in the other closely correlated dimension. The conceptual model will be based on this. Pearson correlation was used to determine the interactions between the dimensions. The results are shown in Table 5. The "r" value based on the direction of the relationships of all dimensions showed a positive correlation; improvements in one dimension would result in improvement in the other in the case of all dimensions. The strength of the relationships is interpreted based on guidelines suggested by Cohen (1988);

r=.10 to .29 or r=–.10 to –.29	small
r=.30 to .49 or r=–.30 to –.4.9	medium
r=.50 to 1.0 or r=–.50 to –1.0	large

In all dimension correlation coefficient (r) indicated a strong relationship. From the results of the r and sig. value in Table 5, it can be concluded addressing issues in finance/admin and others dimension would increase the effectiveness and efficiency of the waste minimization model by a 99% confidence level: r=0.623, p=0.003 with relation to services; r=0.602, p=0.005 with relation to equipment and r=0.711, p=0.001 with relation to others. Also others dimension would increase the efficiency and sustainability of the waste minimization model by a 99% confidence level: r=0.618, p=0.004 with relation to services; r=0.675, p=0.001 with relation to equipment and r=0.711, p=0.001 with relation to finance/admin. Based on the findings the conceptual model; Figure 10 is proposed for a more efficient and sustainable solid waste management.

5.0 Conclusions

It is of importance for a basic waste collection service to be established and available in all districts of the FCT Abuja with a separate management system for hospital waste, but this will prove a difficult task when the institutional body is not integrated and laws are not clearly stated or comprehensive guideline needs to be adopted or formulated, modified for each aspect of WM processes. Towards enabling staff to follow clearly stated duties and procedures required. The institutions responsible for waste management need to be integrated under a single body with the proper instrument put in place to enable its proper function (guidelines). If waste management in FCT Abuja is to succeed sustainable approached in all areas of waste management need to be integrated into the system thereby the proposed conceptual model in Figure 10 developed form the finding of the assessment making the models more suitable for the case study area.

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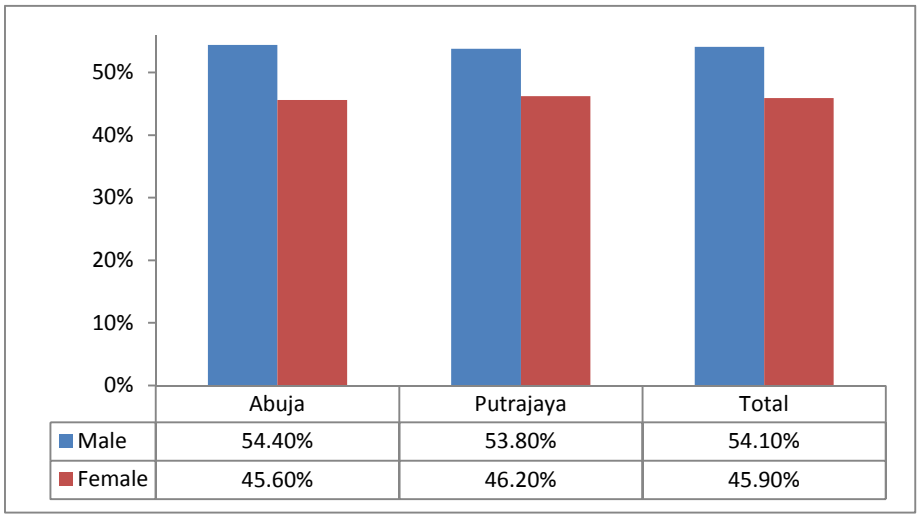
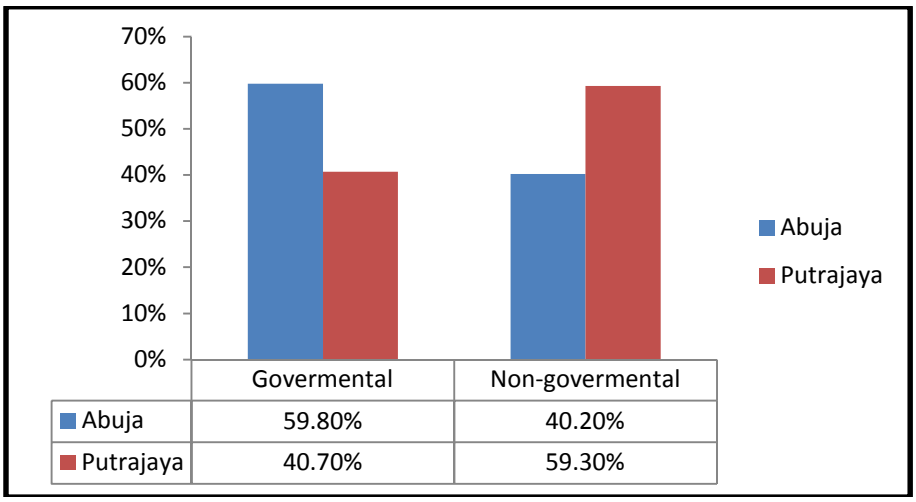


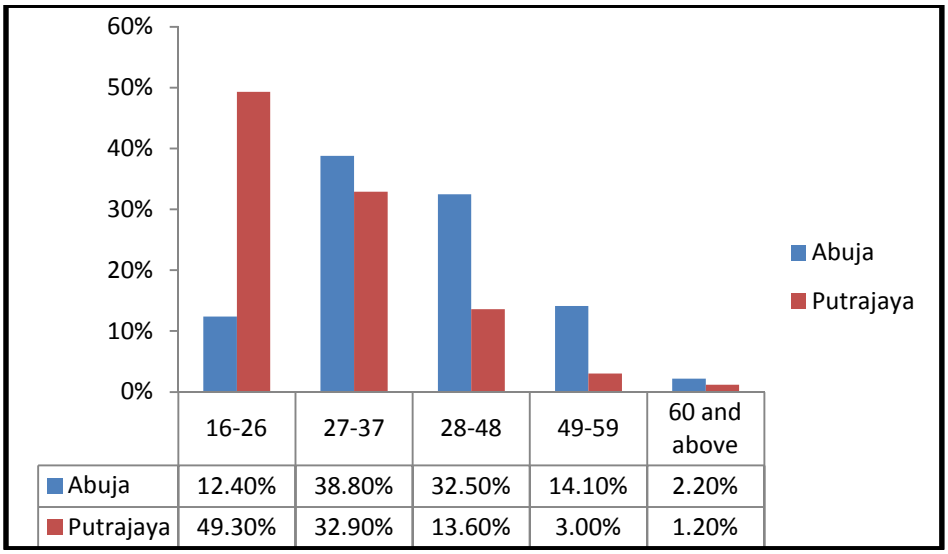
	Abuja	Putrajaya	Total
Male	54.40%	53.80%	54.10%
Female	45.60%	46.20%	45.90%

Figure 1: Shows the frequency distribution of respondent's gender



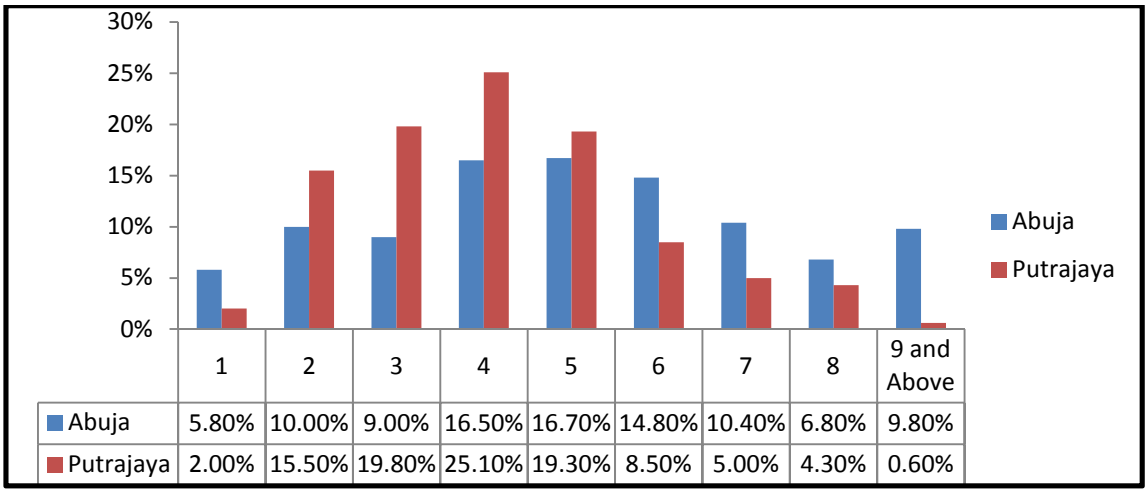
	Govermental	Non-govermental
Abuja	59.80%	40.20%
Putrajaya	40.70%	59.30%

Figure 2: Shows the frequency distribution of respondent's based on occupational categories



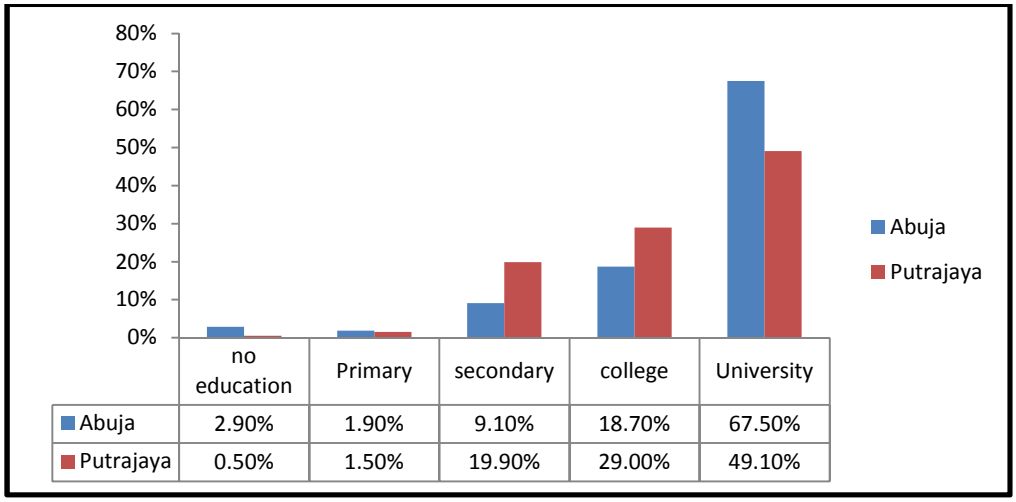
	16-26	27-37	28-48	49-59	60 and above
Abuja	12.40%	38.80%	32.50%	14.10%	2.20%
Putrajaya	49.30%	32.90%	13.60%	3.00%	1.20%

Figure 3: Shows the frequency distribution of respondent's age group



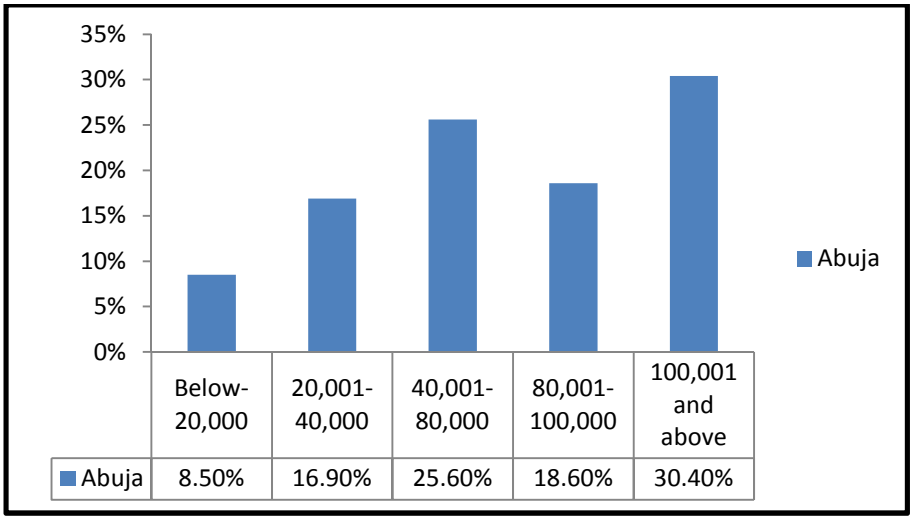
	1	2	3	4	5	6	7	8	9 and Above
Abuja	5.80%	10.00%	9.00%	16.50%	16.70%	14.80%	10.40%	6.80%	9.80%
Putrajaya	2.00%	15.50%	19.80%	25.10%	19.30%	8.50%	5.00%	4.30%	0.60%

Figure 4: Shows the frequency distribution based on number of individuals per household



	no education	Primary	secondary	college	University
Abuja	2.90%	1.90%	9.10%	18.70%	67.50%
Putrajaya	0.50%	1.50%	19.90%	29.00%	49.10%

Figure 5: Shows the frequency distribution of respondent's level of education



	Below-20,000	20,001-40,000	40,001-80,000	80,001-100,000	100,001 and above
Abuja	8.50%	16.90%	25.60%	18.60%	30.40%

Figure 6: Shows the frequency distribution based on total family income in FCT Abuja

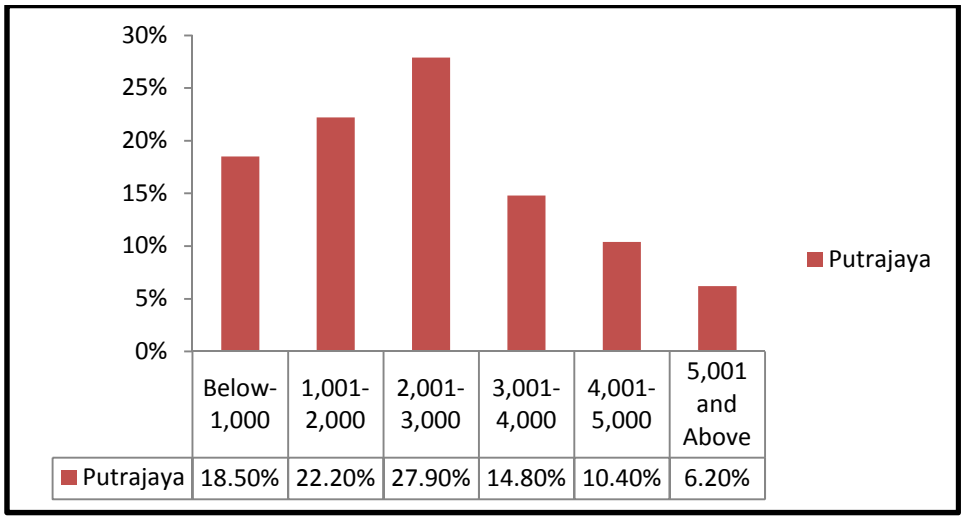


Figure 7: Shows the frequency distribution of respondent's total family income in Putrajaya

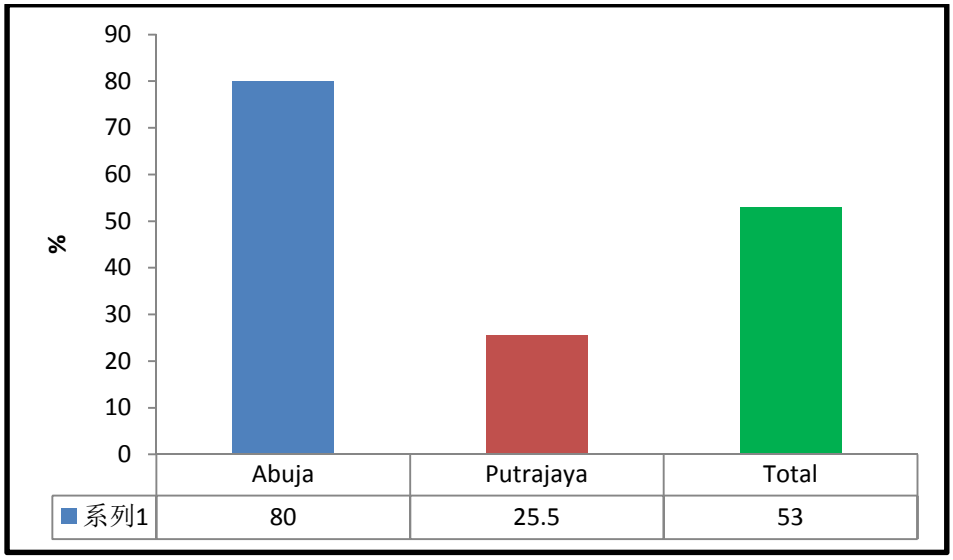


Figure 8: Frequency of respondents with open dumps within area of resident

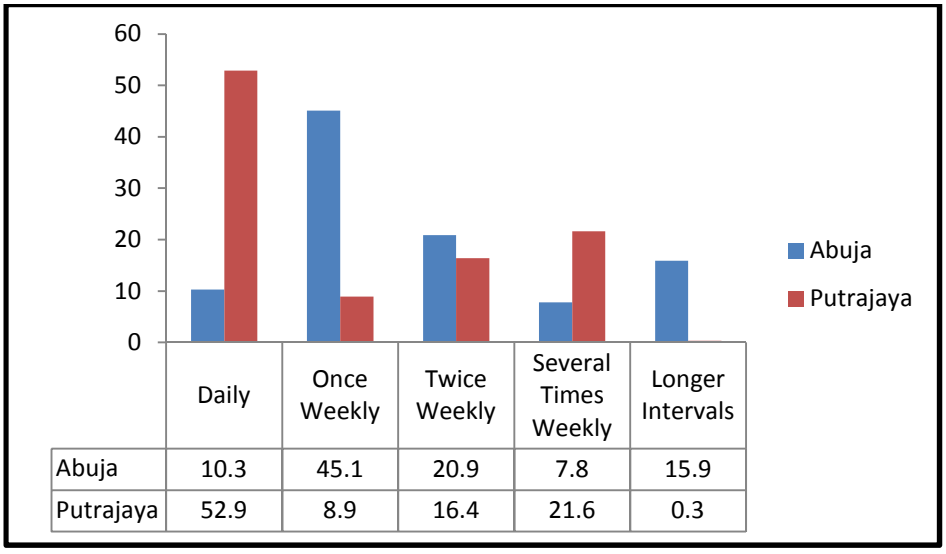


Figure 9: Frequency of waste collection in FCT Abuja and Putrajaya

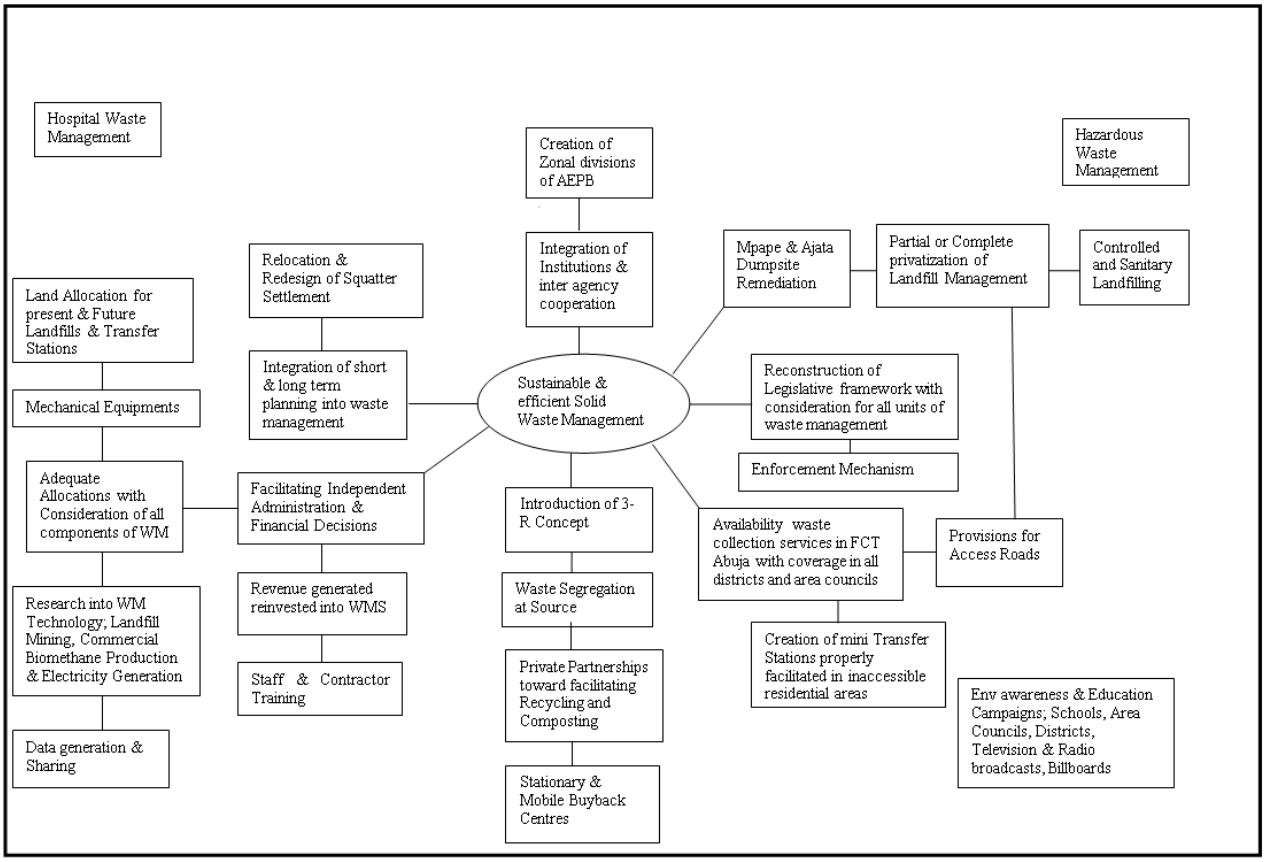


Figure 10: Conceptual Model for FCT Abuja for efficient and Sustainable Solid Waste Management

Table 1: Results for the comparison of both cities based on open dumps within area of resident

	Open dumps
Mann-Whitney U	36906.000
Wilcoxon W	119527.000
Z	-15.504
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: CITY

Table 2: Results of Chi-Square Tests to compare waste collection frequencies in both cities

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	280.249[a]	4	.000
Likelihood Ratio	316.239	4	.000
Linear-by-Linear Association	49.240	1	.000
N of Valid Cases	743		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 28.02.

Table 3: Dimensions

Dimension A: Services	Dimension B: Equipment
PA; Inadequate service coverage (some people not given service) PB; Lack service quality (not frequent enough, spill, etc.) PP; Rapid urbanization outstripping service capacity PR; Difficult to locate and acquire new landfill site PS; Difficult to obtain soil for cover material	PF; Lack of vehicle PG; Lack of equipment PH; Old vehicle/equipment frequent breakdown PI; Difficult to obtain spare parts PJ; Lack of capability to maintain/repair vehicle/equipment PK; No standardization of vehicle/equipment
Dimension C: Finance & Administrative	**Dimension D: Others**
PC; Lack of authority to make financial and administrative decision PD; Lack of financial resources PE; Lack of trained personnel PL; No proper institutional set-up for solid waste management service PM; Lack of legislation PN; Lack of enforcement measure and capability PO; Lack of planning (short, medium and long term plan) PT; Poor cooperation by Government agencies PX; Lack of qualified private contractors PY; Difficult to control contractual service PZ; Lack of control on hazardous waste	PQ; Uncontrolled proliferation of squatter settlements PU; Poor public cooperation PV; Uncontrolled use of packaging material PW; Poor response to waste minimization (reuse/recycling)

Table 4: Reliability Analysis for total dimensions

Dimension	Mean	SD	No. of Items	Alpha
A	13.65	2.92	5	0.625
B	14.75	5.359	6	0.952
C	31.55	6.4	11	0.863
D	9.9	3.35	4	0.885
Total	69.85	15.44	26	0.94

Table 5: Results of Pearson correlation for all dimensions

		services	equipment	Finance/admin	others
services	Pearson Correlation	1	.555*	.623**	.618**
	Sig. (2-tailed)		.011	.003	.004
	N	20	20	20	20
equipment	Pearson Correlation	.555*	1	.602**	.675**
	Sig. (2-tailed)	.011		.005	.001
	N	20	20	20	20
Finance/admin	Pearson Correlation	.623**	.602**	1	.711**
	Sig. (2-tailed)	.003	.005		.000
	N	20	20	20	20
others	Pearson Correlation	.618**	.675**	.711**	1
	Sig. (2-tailed)	.004	.001	.000	
	N	20	20	20	20

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).