DETERMINANTS OF SUSTAINABLE SOLID WASTE MANAGEMENT: A CASE OF CONSTRUCTION PROJECTS IN IMENTI NORTH, MERU COUNTY

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ABSTRACT

Solid waste is made up of hazardous materials that are mostly non-biodegradable, construction solid waste mostly in the form of; broken tiles, steel, Polyvinyl Chloride (PVC) and metal pipes, concrete debris, metal, glass, plastic and gypsum presents huge sustainable management challenges. This is particularly so in construction projects sites that lack low-waste and recycling technology, disposal equipment and in which construction workers are equipped with low levels of education and training. The current study specifically investigated factors that influence the sustainable management of construction solid waste in project sites. Research focused on the influence of; design approaches and management, education and training programs, industry targeted programs and low waste technology and recycling equipment. The research was pivoted on two theories; Balance Theory of Recycling Construction and Demolition Waste and Task-contextual Theory. The study was guided by a descriptive survey research design. Target population 3,055 respondents. Study's sample size was of 16, Consultants (Architects, Contractors and Quantity Surveyors), 287 Clients (Landlords that are members of Imenti North Meru Landlords association) and 39 Meru County Government's Department of water, environment and sanitation staff that was selected to participate in the study. Stratified sampling and Simple random sampling was employed to select the respondents. Questionnaires were used to collect data in the study locale. Data was analyzed qualitatively and quantitatively using SPSS version 22.0, this was presented in frequency and percentage tables and Pearson-Product Correlation was applied. The study found that design approaches and management, education and training program, industry targeted programs and low waste technology and recycling equipment on the sustainable management of construction projects solid waste in Imenti North. The study concluded that design approaches and management had the greatest influence on sustainable management of residential construction solid waste followed by education and training programs then low waste technology and recycling equipment while had the industry targeted programs then least effect on the sustainable management of residential construction solid waste. The study recommends that awareness of the benefits of solid waste management should be created and the general population mobilized, that project managers in Meru County should diversify the form of waste disposal used, that the county government can formulate programs and education/training packages to empower the residents in solid waste reduction and segregation and that government should design better approaches on waste management and help create markets for waste materials through policy making, economic incentives, regulations, enforcement of regulations, and campaigns/promotions.

Key Words: *sustainable solid waste management, construction projects, Imenti North, Meru County*

INTRODUCTION

Hazardous to the environment, construction waste is mostly made of non-biodegradable materials; broken tiles, steel, timber, Polyvinyl Chloride (PVC) pipes and metal, concrete debris, metal, glass, plastic and gypsum (Cha, Kim & Han, 2009). Studies show that this is not a less developed countries challenge only but an environmental issue in developed counties as well (Tam & Lu, 2016; Giwa & Peng, 2013; Li & Zhang, 2012). In the United States (U.S) reports show construction sites waste in particular wood and gypsum contributing to 42% and 27% of Municipal Solid Waste (MSW) respectively (United States Environmental Protection Agency, 2009). Further, countries such as Spain and Poland are reported to recycle 20% of their construction sites solid waste while in Australia, Japan, Hong Kong and Italy construction waste is reported to be at 44%, 36%, 38% and 30% respectively (BIO Intelligence Service, 2011). Construction projects' solid waste contributes to 30%-40% of MSW in China (Qiu, 2010).

In the United States (U.S), Laquatra and Pierce (2011) reported that Industry targeted programs in the form of charge schemes and high levels of education positively influenced endeavors to sustainably manage construction projects solid waste management (CSWM) leading to 75% of this type of waste recycled in local towns in the city of Portland. Reduction in design variations on residential and commercial buildings through contractual obligation that enhanced design management reduced construction solid waste by 30% in Canada (Mendis, Hewage & Wrzesniewski, 2015). In Malaysia, Saadi, Ismail and Alias (2016) established lack of Industry targeted programs in particular failure to create of awareness campaigns on reduction, reuse and recycling of construction waste and to provide landfills negatively influenced sustainable management of construction solid waste. Thomas and Wilson, (2013) reported that poor design approaches and management negatively influenced the sustainable management of construction solid waste in construction sites in India. Inadequate training and low levels of education among construction workers was reported to contribute to the unsustainable management of construction solid waste material which amounted closely to 30%-40% of Municipal Solid Waste (MSW) in mainland China (Yuan,Sheng & Wang 2011). The lack of low-waste technology and equipment and inadequate design management characterized by numerous variations in design were responsible for 57% of construction projects solid waste negatively influencing its sustainable management in Thailand (Manowong, 2012).

In Nigeria, Wahab and Lawal (2011) reported that issues related to design approaches and management causing design changes adversely influenced the sustainable management of construction projects sites solid waste. In Ghana, Agyekum, Ayarkwa and Adinyira (2012) reported lack of low-waste technology and recycling equipment adversely influenced the sustainable management of construction solid waste in 65% of construction project sites under study. Un-reliable Industry targeted programs characterized by failure to provide landfills and unclear legislation on charge schemes adversely influenced the sustainable management of construction solid waste resulting to its 53% increase in construction projects sites in Cape Verde (Vaz, Pontual, Mainier & da Motta, 2016).

STATEMENT OF THE PROBLEM

Forming a significant percentage of Municipal Solid Waste (MSW), construction solid waste constituting; broken tiles, concrete debris, steel, timber, metal, glass, packaging, plastic and gypsum continues to litter construction project sites in major administrative constituencies and accumulate in landfills around the world. Thought to be an important preventive infectious diseases strategy and an environmental protection measure, the degree of sustainable management of construction solid waste through practices such as reduction, re-use and recycling in Imenti North continues to be low. This emanating from lack of low-waste and recycling technology, disposal equipment and low levels of education and training among construction workers and inconsistency in design approaches and management during construction. Further, the unsustainable disposal of residential construction solid waste by contractors and clients in the town continues unabated. This party attributed to failure by those charged with the responsibility of ensuring the environment in Meru County is protected and conserved. In particular, Meru County government's department of Water, Environment and Natural resources has failed to both enforce county laws on management of construction solid waste and implement initiatives that would enhance its sustainable management. Substandard policy measures have also been identified as contributors to the unsustainable management of this type of waste. This has been found to lead to; blocked roads, air pollution, clogged drainage systems contributing to water borne diseases and litter in construction sites' neighboring areas in Imenti North. This study therefore sought to unpack the influence of; design approaches and management, education and training programs, industry targeted programs and low waste technologies and recycling equipment in the sustainable management of residential construction solid waste.

PURPOSE OF THE STUDY

The purpose of the study was to investigate determinants of sustainable management of solid waste management with specific reference to construction projects in Imenti North Meru County, Kenya.

OBJECTIVES OF THE STUDY

1. To establish the influence of design approaches and management on the sustainable management of construction projects solid waste in Imenti North.
2. To assess the influence of education and training programs on the sustainable management of construction projects solid waste in Imenti North.
3. To determine the influence of industry targeted programs on the sustainable management of construction projects solid waste in Imenti North.
4. To examine the influence of low waste technology and recycling equipment on the sustainable management of construction projects solid waste in Imenti North.

THEORETICAL FRAMEWORK

Balance Theory of Recycling of Construction and Demolition (C&D) Waste

Developed by Wong and Yip, (2002) the Balance Theory of Recycling Construction and Demolition (C&D) Waste is based on the premise that construction waste from construction sites can be reduced through waste sorting and recycling. Additionally, they argued that this could best be realized through both the establishment of recycling facilities and the training of construction workers on better on site construction waste sorting techniques (Wong & Yip, 2002). Further, Park and Tucker (2016) proponents of the theory argued that the sustainable management of construction waste materials through reuse is highly reliant on the training of construction workers on the importance of construction waste reuse. This it is argued creates a culture of waste sorting, reuse and sustainable disposal for recycling (Park & Tucker, 2016).However, sustainable management of construction solid waste through recycling can only be achieved when the amount of waste generated on site and delivered for recycling process is proportional to the amount of the recycled C&D products imported and utilized as building materials for that particular residential project (Wong & Yip, 2002).

The Balance Theory of Recycling Construction and Demolition (C&D) Waste is employed to address issues raised by research study variables; education and training programmes and low waste technology and recycling equipment. It assists the researcher to make the argument that sustainable management of construction projects solid waste is influenced by; training of construction workers in sorting of waste, reduction, reuse and technical recycling skills and it is also influenced by the use prefabricated components and large panel steel formwork in construction projects.

Task-contextual Theory

Developed by Motowidlo, Borman and Schmit (1997) the Task-Contextual theory is based on the premise that the best technique to establish competencies that are essential for a job is to appreciate both the task and contextual demands of the job. Further, they observed that there exist variations in individual personality and cognitive capability, coupled with learning experiences leading to the divergent levels in knowledge, skills and occupational customs that moderate effects of personality and cognitive capability on job performance (Motowildo et al., 1997). Additionally, Motowildo et al., (1997) posit that the technical core determines task performance which is done by undertaking the technical demands of the job while the contextual competencies are associated to the personality, behavior and motivation and it is to a greater extent optional or supportive by design.

Ajayi et al., (2016) proponents of the theory note that the sustainable management of construction solid waste materials is heavily reliant on design task proficiency, low waste design skills and construction linked knowledge that are indispensable task competencies on the other hand they observe that behavioural competence and inter-professional collaborative capabilities

are essential contextual competencies for designing out waste. Further, they contend that there is therefore need to improve designers' competencies by addressing their training needs and also enhancing the attitudes of construction workers on sustainable management of construction solid waste making use of awareness campaigns that appeal to their self conviction and inclination to waste mitigation (Ajayi et al., 2016).

The Task-Contextual theory is employed to address issues raised by research study variables; design approaches and management, education and training programmes and industry targeted programmes. It assists the researcher to make the argument that sustainable management of construction projects solid waste is influenced by; kinds of knowledge, skills, work habits, and traits of consultants, construction workers and their clients. Additionally, it is influenced by training of construction workers in sorting of waste, reduction, reuse and technical recycling skills and it is also influenced by the use industry targeted programs that entail awareness campaigns and economic incentives for the sustainable management of construction projects solid waste.

RESEARCH METHODOLOGY

Research Design

The current research made use of a descriptive survey research design to undertake an into determinants of solid waste management with specific references to construction projects solid waste in Imenti North, Meru County, Kenya. The choice of survey research design was informed by its inherent features that aided the gathering of information on the prevailing state of affairs and also comprehensively portrays characteristics of the population of study (Salaria, 2012). Additionally, the choice of descriptive survey research design is informed by its capability for to facilitate the gathering of qualitative as well as quantitative data on the relationship between variables under research establishing the link between study variables and problem under investigation (Vogt, Gradner & Haeffele, 2012).

Target Population

According to the National Construction Authority (NCA) there are 41 duly registered consultants; Architects, Contractors and Quantity Surveyors in Imenti North while the Landlords Association-Meru branch has 2,876 duly registered members and County government of Meru has 126 staff at the Department of water, environment and sanitation. The current study's target population was therefore 3,055 respondents in the researcher's study locale. These respondents are ideal for the gathering of the current study's required data because the variables under investigation as well as their existing correlation with respect to the topic under investigation are well known to them. This was summarized in Table 3.1 on target population

Sample Size and Sampling Procedure

Sampling is the procedure employed to select units of a population to work as representation of the total population. For the current research study, Stratified and Simple Random sampling was used (Emmel, 2013). This sample size was obtained by applying the formula:

$$Ns = (Np)(p)(1-p)$$

$$(Np-1)(B/C)\,2 + (p)(1-p)$$

$n = (Z^2 \cdot PQ/\alpha^2)$ by Dillman, (2007).

342 respondents drawn from a targeted population of 3,055 formed the sample size for the study.

The sample size was computed as follows:

At 95% confidence level or probability of 0.05, sample size n can be calculated as:

Desired sample $n=(Z^2 \cdot PQ/\alpha^2)$

Where: Z= Critical value of Z at 0.05 which is equal to 1.96; P=Accessible proportion of the target population= 50%; Q= In accessible proportion of the target population=50%; The acceptance error estimate = α.

Using the above formula, the maximum sample size (n_o) required from a large population of 10,000 or more units would be 384 units. The sample size can be adjusted with respect to target population as:

The adjusted sample size $n_1 = n_o/(1+n_o/N)$.

Where: N is the size of the target population in the area of study

The adjusted sample size $n_1=1+384/(1+384/3,055) =342$

384/3055 = 0.126, 0.126+1= 1.126, 1+384 =385,

385/1.126 = 342

$n_1 = 342$

For the current study stratified sampling was employed to ensure proper representation of the different study respondents from each stratum to enhance representation of variables related to them. Simple random sampling was then used as the unit of analysis to distribute final sampled study subjects from dissimilar strata represented by each of them (Steven, 2012).

Research Instruments

The current study's primary data was collected through the use of questionnaires. Defined as a properly designed investigation tool a questionnaire facilitates researchers to gather information from final study sampled subjects on their traits, current and past behavior, viewpoints or code of conduct and their beliefs and or their rationale for action with respect to the problem under research (Bell, 2010). The choice of this research instrument was guided by its inbuilt advantages including; it's been free from the interviewee prejudicial tendencies and granting respondents sufficient time to provide well thought out responses. The current study's questionnaire incorporated closed as well as open ended questions. Its closed questions were made up of a fixed set of questions whose target respondents are; consultants, clients and staff at county government's department of water, environment and sanitation in an itemized pattern and with classified response options. On the other hand, respondents were not experience restrictions in answering the questionnaires' open-ended questions but they freely revealed required information. The questionnaire was divided in 6 sections. Section one requested the final study's sampled subject to fill in his or her background information, whereas the remaining 5 sections incorporated variables under investigation in the current research study. The sections were; Design Approaches and Management, Education and Training Programs, Industry Targeted programs, Low Waste Technology and Recycling Equipment and sustainable management of construction projects solid waste.

Data Collection Procedures

Primary data was collected through the use of self-administered questionnaires and the drop and pick later technique to the final sampled study's subjects was applied. Additionally, the current research study employed the use structured questionnaires and this choice is anchored on design nature of these research tools which presents each item with a set of choice answers and is also economical in terms of time and money (Saris & Gallhofer, 2014). The desired response rated was achieved by developing a register record of administered questionnaires which facilitated their tracking.

Data Analysis

Collected primary data was sorted, edited, coded and analyzed to ensure that comprehensibility and reliability of research tools are upheld. For purposes of creating a detailed abstraction of how the data looked like and to facilitate the identification of pattern, quantitative data from individual research questions were also tabulated. Additionally, to achieve dependable analysis, SPSS version 22.0 was used to analyze gathered primary data from which findings were presented making use of descriptive statistic guided by; frequencies, mean, variance and standard deviation. The researcher made use of results of the analysis to arrive at justifiable conclusions on the subject under investigation. Data from open ended questions were analyzed making use of content analysis and results from this analysis were presented in themes guided by the objectives

of the current study. Information from this was summarized by employing frequencies and percentages. To ascertain the existence of a significant or insignificant relationship between any two of the study's variables between and the distinct unique significance of each of the study's four variables in with respect to the sustainable management of construction projects solid waste in building construction sites in the locale of the current study, Pearson Product-Moment correlation (Pearson r) was employed (O'Brien & Scott, 2012). In particular a linear correlation between any two of the research study's predictor variables were determined and their unique influence on the dependent variable established.

INFERENTIAL STATISTICS

The researcher conducted both the Pearson correlation analysis and the regression analysis. The regression analysis was used to establish the relations between the independent and dependent variables while correlation was conducted to assess the degrees of association between the variables.

Pearson Moment Correlation Results

This was conducted to assess the degrees of association between the variables. A Pearson moment correlation is a number between -1 and +1 that measures the degree of association between two variables. A positive value for the correlation implies a positive association while a negative value for the correlation implies a negative or inverse association. Table 1 shows the results for the Pearson moment correlation.

Table 1: Correlation Coefficients

		Sustainable Management of Residential	Design approaches and	Education and training programs	Industry targeted	Low waste technology and recycling equipment
Sustainable Management of Residential Construction Solid Waste	Pearson Correlation	1				
	Sig. (2-tailed)	.				
Design approaches and management	Pearson Correlation	.817	1			
	Sig. (2-tailed)	.012	.			
Education and training programs	Pearson Correlation	.761	.223	1		
	Sig. (2-tailed)	.001	.006	.		
Industry targeted programs	Pearson Correlation	.618	.243	.497	1	
	Sig. (2-tailed)	.002	.002	.000	.	
Low waste technology and recycling equipment	Pearson Correlation	.729	.333	.420	.531	1
	Sig. (2-tailed)	.017	.000	.000	.000	.

The analysis of correlation results between the Sustainable Management of Residential Construction Solid Waste and Design approaches and management shows a positive coefficient 0.817, with p-value of 0.012. It indicates that the result is significant at α =5% and that if the design approaches and management increase it will have a positive impact on the sustainable management of residential construction solid waste. The correlation results between education and training programs and sustainable management of residential construction solid waste also indicates the same type of result where the correlation coefficient is 0.761 and a p-value of 0.001 which significant at α = 5%.

The results also show that there is a positive association between industry targeted programs and sustainable management of residential construction solid waste where the correlation coefficient is 0.618, with a p-value of 0.002. Further, the result shows that there is a positive association between low waste technology and recycling equipment and sustainable management of residential construction solid waste where the correlation coefficient is 0.729, with a p-value of 0.017. Nevertheless, the positive relationship indicates that when the practice of the afore-mentioned factors is in place the levels of sustainable management of residential construction solid waste increases.

Overall, design approaches and management had the greatest effect on sustainable management of residential construction solid waste followed by industry targeted programs then education and training programs while low waste technology and recycling equipment had the least effect on the sustainable management of residential construction solid waste.

Regression Analysis

In this study, a multiple regression analysis was conducted to test the influence among predictor variables. The research used statistical package for social sciences (SPSS V 21.0) to code, enter and compute the measurements of the multiple regressions. The model summary are presented in the Table 2.

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.837	0.701	0.696	0.990

The study used coefficient of determination to evaluate the model fit. The adjusted R2, also called the coefficient of multiple determinations, is the percent of the variance in the dependent explained uniquely or jointly by the independent variables. The model had an average adjusted coefficient of determination (R2) of 0.696 and which implied that 69.6% of the variations in sustainable management of residential construction solid waste are explained by changes in design approaches and management, education and training programs, industry targeted programs and low waste technology and recycling equipment.

The study further tested the significance of the model by use of ANOVA technique. The findings are tabulated in Table 3.

Table 3: Analysis of Variance (ANOVA)

Model		Sum of Squares	Df	Mean Square	F	Sign.
1	Regression	566.126	4	141.532	142.607	.000
	Residual	241.168	243	0.992		
	Total	807.294	247			

From the ANOVA statics, the study established the regression model had a significance level of 0.00% which is an indication that the data was ideal for making a conclusion on the population parameters as the value of significance (p-value) was less than 5%. The calculated value was greater than the critical value (142.607>2.4088) an indication that design approaches and management, education and training programs, industry targeted programs and low waste technology and recycling equipment all have a significant effect on sustainable management of residential construction solid waste. The significance value was less than 0.05 indicating that the model was significant.

In addition, the study used the coefficient table to determine the study model. The findings are presented in the Table 4.

Table 4: Regression Coefficients

	Un standardized Coefficients		Standardized Coefficients	t	Sig
	B	Std. Error	Beta		
(Constant)	0.912	0.112		8.143	.000
Design approaches and management	0.801	0.393	0.817	2.038	.048
Education and training programs	0.711	0.244	0.761	2.914	.006
Industry targeted programs	0.587	0.239	0.618	2.456	.018
Low waste technology and recycling equipment	0.719	0.178	0.729	4.039	.000

The regression equation obtained from this outcome was:

$$\mathbf{Y = 0.912+0.801X_1 + 0.711X_2 +0.587X_3 + 0.719X_4}$$

As per the study results, it was revealed that if all independent variables were held constant at zero, then the Sustainable management of residential construction solid waste will be 0.912. From the findings the study revealed that if design approaches and management increases by one unit, then sustainable management of residential construction solid waste would increase by 0.801. This variable was significant since p=0.048 is less than 0.05.

The study further revealed that if education and training programs changes it would lead to 0.711 change in sustainable management of residential construction solid waste. The variable was significant since p-value=0.006<0.05. Moreover, the study showed that if all other variables are held constant, variation in industry targeted programs variates sustainable management of residential construction solid waste by 0.587. This variable was significant since p=0.018 was less than 0.05. Finally, the study revealed that variation in low waste technology and recycling equipment would change the sustainable management of residential construction solid waste by 0.719. This variable was significant since p-value=0.000 was less than 0.05.

Generally, design approaches and management had the greatest influence on sustainable management of residential construction solid waste followed by education and training programs then low waste technology and recycling equipment while had the industry targeted programs then least effect on the sustainable management of residential construction solid waste. All the variables were significant since p-values were less than 0.05.

CONCLUSIONS

In imenti North, sustainable management of construction projects solid waste is positively and significantly influenced by design approaches and management. It was clear that sustainable management of residential construction solid waste is not influenced by poor site coordination arising from poor communication but influenced by the number of rework incidents. Further it was established that number of design variations and design enquiries influence the sustainable management of residential construction solid waste.

Education and training programs were found to positively and significantly influenced the sustainable management of construction projects solid waste in Imenti North. This was attributed number of trainings on construction waste reduction that dictates the number of workers with technical recycling skills. Also, the number of number of workers with professional construction skills influence the sustainable management of residential construction solid waste.

The study also concluded that industry targeted programs have a positive influence sustainable management of construction projects solid waste in Imenti North. It was clear that the number of charge schemes and recycling incentives has influence on sustainable management of residential construction solid waste. Moreover, the it was clear that number of awareness campaigns does not influence the sustainable management of residential construction solid waste.

Low waste technology and recycling equipment was further concluded to positively and significantly influence sustainable management of construction projects solid waste in Imenti North. It was clear that number of buildings using prefabricated technologies and that the existence of buildings using large panel steel formwork influence on sustainable management of residential construction solid waste. Further it was revealed that the number of concrete debris crushers on site does not influence the sustainable management of residential construction solid

waste and that existence of plastic shredders and granulators on site has influence on the sustainable management of residential construction solid waste.

RECOMMENDATIONS

The study recommends that awareness of the benefits of solid waste management should be created and the general population mobilized. The county government should be the initiator of community participation. The several methods studied would be effective in changing mindset of the population. The TV media, public Barraza's, posters and person to person should be utilized depending on the budgets available.

The project managers in Meru County should diversify the form of waste disposal used. This will enable them to address the different nature of waste produced in the county. Different types of waste that are generated in a county require different methods to address the problem of waste disposal the more options the county has in methods of disposal the more they are able to address different types of wastes generated.

The county government can formulate programs and education/training packages to empower the construction workers and contractors on management of building design and the sustainable management and disposal of construction solid waste. This will aid towards achieving the zero-waste principle. This informed by the positive attitude by public hospital management to be involved and trained in solid waste management. The study also recommends that public hospitals management should organize educational activities such as the organisation of conferences, seminars and workshops, publication of training manuals, case studies and best practices, and provision of technical and financial assistance should also be conducted.

The government should design better approaches on waste management and help create markets for waste materials through policy making, economic incentives, regulations, enforcement of regulations, and campaigns/promotions. By recognizing and giving awards to best practices in waste management, the government would help increase the public's awareness of initiatives and encourage others to adopt similar approaches. The county government could help establish the residential solid waste committees. This will create a forum of communication, engagement and working together between the households and the department in solid waste service provision. This is supported by the citizen participation theory.

Government should allocate enough budget for provision of low waste technology and recycling equipment within Meru county which should be reviewed periodically to ascertain if the monies are put to correct use and to ensure efficient effective Solid Waste Management. The government should encourage the development of better waste management through waste reduction, reuse, recycling and composting. As the facilitator for waste management program development (using concepts such as the polluter pays principle and cleaner production), the government should support businesses and communities through pilot projects, funding, training, technical assistance, information exchange, follow-up support and monitoring.

The government should encourage better waste management practices and help create markets for waste materials through policy making, economic incentives, regulations, enforcement of regulations, and campaigns/promotions. By recognizing and giving awards to best practices in waste management, the government would help increase the public's awareness of initiatives such as the SWM program and encourage others to adopt similar approaches.

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