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An Investigation of Waste Management Practices in the Zambian Construction Industry

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Abstract

This study investigated the practice and perceptions on waste management and the feasibility of establishing a site waste management plan in the Zambian Construction Industry (ZCI). In this research, Lusaka and the Copperbelt provinces were selected as study areas to represent the construction industry in Zambia. This was because the largest volume of construction work in the country is mainly concentrated in these two provinces. The research targeted contractors from Grades 1 to 3 as categorised and registered by the Zambian National Council for Construction (NCC). Consultancy firms and government institutions were also included in the target population as regulators. Data for this study were obtained through questionnaires, interviews and site surveys. The results from this research indicated that disposal was the most common method of waste management in the Zambian Construction industry as indicated by the highest ranking score with a mean index of 0.923. The research concluded that the construction industry in Zambia has poor practice of waste management through waste disposal which is not environmentally friendly. The results further indicated that it is feasible to adopt a Site Waste Management Plan in the Zambian Construction industry based on the respondents' willingness mean score of 0.94 from all the categories. Finally, the research confirmed that a Site Waste Management Plan can be an effective tool to address waste management challenges in the Zambian Construction Industry based on the literature review and willingness measured from research respondents.

Keywords

Waste Management, Sustainable Management, Disposal, Construction Waste

1. Introduction

Baldwin *et al.* [1], state that construction waste is produced from a range of construction activities and materials. However, it is must be mentioned that not every activity and material will produce equal amount of construction waste. According to Arslan, *et al.* [2], sources of waste include unused materials, incorrect materials, surplus stencils or nails, packages of construction materials or components, surplus concrete materials resulting from fractures or deformations due to improper storage or preservation of construction materials and components arriving at the construction site. Others include poor material handling, erroneous cuttings, improper or faulty equipment, poor storage facilities, poor workmanship and inaccurate measurements. Most of the waste generating factors identified above originate mainly from site operations and general residual, Osmani *et al.* [3]. With so many sources of waste generation, this study set out to investigate waste management practices in the Zambian Construction Industry (ZCI). While studies have been previously done in the field, this particular research aimed at measuring waste management practice and perceptions. Previous studies done in Zambia include minimising construction waste generation through design by Muleya and Muyoba [4]. Another recorded study done by Lwanga [5], focused on the investigation on re-using construction waste for sustainable development with particular attention to concrete waste. Much of the research has in the past concentrated on household waste with little attention to other sectors such as construction. A study by Edema *et al.* [6] revealed that a study on the Copperbelt province of Zambia showed that lack of environmentally friendly, sustainable and affordable waste management had led to the wide spread open dumping and open burning of solid waste. In another study that included Zambia and reported in the Africa Review Report on waste management [7], it was concluded that poor waste management practices in particular the widespread dumping of wastes in water bodies and uncontrolled dump sites aggravates the problems of generally low sanitation levels across the African continent.

This study finally considered the feasibility of respective perspectives of stakeholders regarding the use of a Site Waste Management Plan (SWMP) as a method of mitigating the generation of construction waste from the design through to the construction phase.

2. Background and Research Justification

Construction site waste has been labelled to be one of the major problems in the construction industry that presents significant implications on the efficiency in the industry as well as the adverse impacts on the environment, Formoso *et al.*, [8]. According to the United Nations Environment Programme [9] construction and demolition waste in the European Union made up 38.2% of the total waste generated in 2006. However, it has been stated that the solution can be found by including the waste management aspects in the planning process, carefully giving attention to the important issues it raises, United Nations Environment Programme, [9]. Based on the Africa review report on waste management [7], which centres on four countries namely; Ghana, Egypt, Kenya and Zambia, it was stated that gaps exist that hinder environmentally sound management of waste. Some of the identified gaps include; Policy and planning, legal aspects including enforcement, key stakeholders roles and coordination, capacity building and training, public awareness, staff, equipment, finance and cost recovery, Mwesigye, *et al.* [7]. Commenting on the aspect of Policy and Planning at national level it was established that, in the Kenyan case it is still a significant challenge to enforce the law regarding waste management because of the absence of a National Waste Management Policy. The other problem established was that Waste Management Strategies or Plans have not been embraced by all stakeholders in the country, Mwesigye, *et al.* [7]. Mahayuddin *et al.* [10] states that construction waste represents large amounts of material that are often illegally dumped by roadsides, river banks and many other open spaces. Urgent and immediate improvement of the construction waste disposal practices is necessary to meet the current demand for improved construction waste management. However, there is very little relevant information on disposal practices for construction waste at the municipal level, including its composition and the disposal site characteristics. The lack of a collection network and insufficient collection of waste from construction sites contributes to illegal dumping. Guerrero *et al.* [11] carried out a study that included the city of Lusaka in Zambia on the solid waste challenges in developing countries. The study however only considered one city in Zambia and further, it did not consider construction waste. Mahayuddin *et al.* [10] further states that lack of sufficient legislation, enforcement and facilities have contributed to poor waste management of construction waste alongside other form of waste in developing countries.

It can be seen clearly that the absence of a Waste Management Plan or framework contributes to the poor management of waste. This is because there are no clear guidelines on how to best handle waste. It was further established that, most of the bidding documents used for building works in Zambia do not have provisions or guidelines that adequately promote sustainable construction waste management. An example would be clause 5.15 of the FIDIC document at Buildings Department Copperbelt Office of Zambia which states in part that the contractor shall, "keep the site clean, clear up and remove all rubbish and debris." This clause does not give any further guidelines to ensure that waste is handled in a more sustainable manner.

However, the documents used in the road sector are clear in promoting sustainable waste management in Zambia. The Special Environmental Specifications section states that, "The contractor shall ensure that all waste including construction waste generated during execution of the Works, is collected and disposed off at designated disposal sites in line with the Waste Management Regulations of the Environmental Council of Zambia or shall be re-used or sold for re-used locally as approved by the Project Manager." The statement goes beyond disposal to include other factors of sustainable waste management such as reuse, which is not the case for building works. The gaps in the management of construction waste constituted the motivation to carry out this research.

3. Aim

The main aim of this research was to investigate and categorise construction waste management practices in the Zambian construction Industry (ZCI).

Objectives

- To investigate and categorise of common waste management practices in the ZCI.
- To investigate the feasibility of adopting a waste management plan in the ZCI.
- To establish and measure the challenges and benefits associated with the adoption of a site waste management plan in the ZCI.

4. Literature Review

According to Tam [12], waste management in the construction industry has not been effectively controlled, and as a result more work must be done in order to reach a satisfactory level of waste management. In the recent past, construction waste was usually disposed in landfills, however, landfill spaces are fast being exhausted hence the need to consider other suitable means to manage construction waste. It has further been argued that construction waste generation and unsustainable use of natural resources as building materials, in the construction industry are related to the negative impact on the environment. It is estimated that approximately 10 to 30 percent of waste disposed of in landfills worldwide originate from construction and demolition activities, Papargyropoulou, *et al.* [13].

4.1. Defining Waste Management

There are numerous definitions available from various authors. Table 1 outlines definitions for some of the terms that are associated with waste management as given by Northumberland National Park Authority [14]. These definitions are well aligned with construction waste management guidelines.

4.2. Origins and Causes of Waste

Commenting on the origin and causes of construction waste, Osmani *et al.* [3]

Table 1. Waste management definition from Northumberland Park Authority [14].

Terminology	Definition
Waste	Waste' means any substance or object which the holder discards, intends to discard, or is required to be discarded.
Waste management	Waste management' means the collection, transport, recovery and disposal of waste, including the supervision of such operations and the after-care of disposal sites and including actions taken as a dealer or a broker.
Recovery	Recovery' means any operation whereby the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy.
Disposal	Disposal' means any operation which is not recovery, even where the operation has a secondary consequence such as the reclamation of substances or energy.

states that waste is actually generated throughout the project from inception to completion. However, it has been accepted generally among researchers that variations which come up while construction is in progress are a major cause of construction waste. Table 2 shows various sources of waste during the project management cycle from inception to completion.

4.3. Site Waste Management Plan

Göttsche [16] states that, "A Site Waste Management Plan (SWMP) is a tool that is used to manage waste on-site." A SWMP provides a framework which can help contractors or project managers to forecast and record the amount and type of construction waste that is likely to be generated on a project, as well as assist in setting up appropriate management actions that reduce the amount of waste that is destined for to landfills, WRAP, [17]. The main aim of a construction SWMP is to improve materials resource efficiency by following the waste hier-

Table 2. Origins and causes of construction waste, Source: Dajadian and Koch, [15]).

Origins of waste	Causes of waste
Contractual	● Errors in contract documents ● Contract documents incomplete at commencement of construction
Design	● Design changes ● Design and construction detail errors ● Unclear/unsuitable specification ● Poor coordination and communication (late information, last minute client requirements, slow drawing revision and distribution)
Procurement	● Ordering errors (i.e., ordering items not in compliance with specification) ● Over allowances (i.e., difficulties to order small quantities) ● Supplier errors
Transportation	● Damage during transportation ● Insufficient protection during unloading ● Inefficient methods of unloading
On-site management and planning	● Lack of on-site waste management plans ● Improper planning for required quantities ● Lack of on-site material control ● Lack of supervision
Material storage	● Inappropriate site storage space leading to damage or deterioration ● Improper storing methods ● Materials stored far away from point of application
Material handling	● Materials supplied in loose form ● On-site transportation methods from storage to the point of application ● Inadequate material handling
Site operation	● Accidents due to negligence ● Equipment malfunction ● Poor craftsmanship ● Time pressure
Residual	● Waste from application processes (i.e., over-preparation of mortar) ● Packaging
Other	● Weather ● Vandalism

archy in employing reuse, recovery and recycling to cut down illegal dumping by recording waste removal processes, Defra, [18]. **Figure 1** shows the waste management hierarchy with disposal being the least desired.

5. Methodology

This study was carried out in Lusaka and the Copperbelt provinces of Zambia, thus representing the Zambian construction industry. The two provinces were selected because they constitute the largest volume of construction works in Zambia. The selection of the two provinces was done through judgmental sampling because they were perceived to meet the requirements of the study as supported by Kumar, [20]. The target groups were basically divided into three groups namely contractors, consultants and government units as regulators. Consultants are responsible for design, specification provision and overall supervision of the construction project. The contractor on the other hand is responsible for the execution and delivery of the works during which waste is generated. Government is responsible for providing legislation and enforcing the law regarding waste management. All three stakeholders play a critical role in construction waste management hence the need to get independent perspectives of what was prevailing in terms of challenges associated with construction waste. Architects and quantity surveyors were selected to participate because they are at the core of project design and contract procurement procedure for building works.

Number of Selected Contractors and Consultants

Tables 3-5 gives a summary of the sample sizes selected for the research:

Tables 6-13 shows the frequency of responses obtained. The tables contain methods of waste management (factors) against the scale of responses (frequency distribution). This in turn enabled the identification of the factor with the highest frequency for the purpose of finding the most occurring method using the Relative Importance Index formula (RII) as given by Tam *et al.* [21].

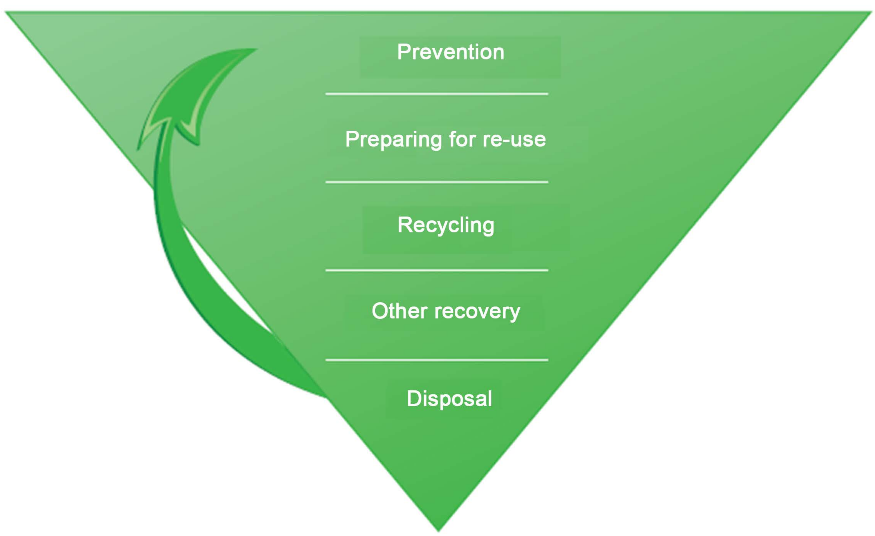

Figure 1. Waste hierarchy (Source: European union, [19]).

Table 3. Selected contractors.

Contractors Grade	Sampling Technique	Population Size	Sample Size	Response Size
One	Stratified sampling	60	**18**	**8**
Two	Stratified sampling	49	**17**	**9**
Three	Stratified sampling	64	**18**	**11**
Total		**173**	**53**	**28**

Table 4. Selected consultants.

Consultancy	Sampling Technique	Population Size	Sample Size	Response Size
Quantity Surveying	Stratified sampling	**30**	**14**	**8**
Architectural	Stratified sampling	**44**	**16**	**11**
Total		**74**	**30**	**19**

Table 5. Selected government institutions as regulators.

Government Institutions	Sampling Technique	Population Size	Sample Size
Environmental authority	Judgemental sampling	**1**	**1**
Local Authority	Judgemental sampling	**1**	**1**
Government Buildings Department	Judgemental sampling	**1**	**1**
Total		**3**	**3**

Table 6. Relative Importance Index and ranking for the method of waste management analysis from contractors.

Item	Method of waste management	Scale and No. of Response					Total	RII	Ranking
		1	2	3	4	5			
a)	Disposal	0	0	0	4	24	28	**0.971**	1st
b)	Reuse	1	4	10	11	2	28	**0.664**	2nd
c)	Reduce	1	6	14	5	2	28	**0.607**	3rd
d)	On-site segregation	3	9	11	4	1	28	**0.536**	4th
e)	Prefabrication	15	7	4	1	1	28	**0.329**	5th
f)	Recycle	19	6	2	1	0	28	**0.293**	6th
g)	Other, state:	-	-	-	-	-	-	**-**	-

Table 7. Relative Importance Index and ranking for the method of waste management from consultants.

Item	Method of waste management	Scale and No. of Response					Total	RII	Ranking
		1	2	3	4	5			
a)	Disposal	0	2	3	0	14	19	**0.874**	1st
b)	Reuse	2	3	7	7	0	19	**0.600**	2nd
c)	On-site segregation	4	2	12	0	1	19	**0.558**	3rd
d)	Reduce	2	6	10	0	1	19	**0.516**	4th
e)	Prefabrication	10	6	0	2	1	19	**0.368**	5th
f)	Recycle	9	9	0	1	0	19	**0.326**	6th
g)	Other, state:	0	0	0	0	0	0	**-**	-

Table 8. Relative Importance Index and ranking for the method of waste management from regulators.

Item	Method of waste management	Scale and No. of Response					Total	RII	Ranking
		1	2	3	4	5			
a)	Disposal	0	0	1	0	2	3	**0.867**	1st
b)	On-site segregation	1	0	1	0	1	3	**0.600**	2nd
c)	Reduce	1	0	2	0	0	3	**0.467**	3rd
d)	Reuse	1	0	2	0	0	3	**0.467**	3rd
e)	Recycle	1	1	1	0	0	3	**0.400**	4th
f)	Prefabrication	2	1	0		0	3	**0.266**	5th
g)	Other, state:	-	-	-	-	-	-		

Table 9. Relative importance index and ranking for familiarity and experience with the activities in SWMPs from contractors.

Item	Activity	Scale and No. of Response					Total	RII	Ranking
		1	2	3	4	5			
a)	Identifying who would be responsible for resource management	1	15	5	3	4	28	**0.557**	1st
b)	Forecasting the types of waste likely to be generated.	6	6	9	5	2	28	**0.536**	2nd
c)	Pre-stating how the waste would be managed, e.g. will it be reduced, reused or recycled etc.	3	15	3	4	3	28	**0.521**	3rd
d)	Identifying which contractors would be used to ensure that waste is managed safely	6	6	12	4	0	28	**0.500**	4th
e)	Estimating the quantity of waste to be generated on the project	18	4	3	2	1	28	**0.343**	5th

Table 10. Relative importance index and ranking for familiarity and experience with the activities in SWMPs from consultants.

Item	Activity	Scale and No. of Response					Total	RII	Ranking
		1	2	3	4	5			
a)	Identifying who would be responsible for resource management	0	7	4	1		19	**0.695**	1st
b)	Pre-stating how the waste would be managed, e.g. will it be reduced, reused or recycled etc.	3	6	6	3	1	19	**0.526**	2nd
c)	Identifying which contractors would be used to ensure that waste is managed safely	5	2	8	3	1	19	**0.526**	2nd
d)	Forecasting the types of waste likely to be generated.	1	9	6	3	0	19	**0.516**	3rd
e)	Estimating the quantity of waste to be generated on the project	9	1	6	3	0	19	**0.432**	4th

Table 11. Relative Importance index and ranking for the likely challenges in the adoption a SWMP in the ZCI from contractors.

Item	Challenge	Scale and No. of Response					Total	RII	Ranking
		1	2	3	4	5			
a)	Lack of experience and training	0	5	6	12	5	28	**0.721**	1st
b)	Construction culture and behaviour	2	5	12	5	4	28	**0.629**	2nd
c)	Poor understanding of SWMP by stakeholders	3	6	10	3	6	28	**0.621**	3rd
d)	Lack of awareness on-site	0	8	14	3	3	28	**0.607**	4th
e)	Low financial incentives	1	8	9	5	5	28	**0.600**	5th
f)	Increased overheads	0	10	9	8	1	28	**0.600**	5th
g)	Time Constraints	3	9	6	7	3	28	**0.586**	6th
h)	Other, state:	0	0	0	0	0	0		

Table 12. Relative importance index and ranking for the likely benefits in the adoption a SWMP in the ZCI from contractors.

Item	Benefit	Scale and No. of Response					Total	RII	Ranking
		1	2	3	4	5			
a)	Environmental benefits	0	2	0	5	21	28	**0.921**	1st
b)	Provides a formally structured approach to on site waste management	0	0	3	10	15	28	**0.886**	2nd
c)	Reduces waste to landfills	0	0	5	7	16	28	**0.879**	3rd
d)	Reduces waste on site and prevents pollution	0	0	3	11	14	28	**0.879**	3rd
e)	Ensures waste is considered through all stages	0	1	7	8	12	28	**0.793**	4th
f)	Allocates resources more efficiently	0	1	12	9	6	28	**0.743**	5th
g)	Produces cost savings	0	1	11	14	2	28	**0.721**	6th
h)	Other, state:								

Table 13. Relative importance index and ranking for method of regulation from government institutions as regulators.

Item	Method of Regulation	Scale and No. of Response					Total	RII	Ranking
		1	2	3	4	5			
a)	Fine the Contractor	1	0	0	1	1	3	**0.667**	1st
b)	Stop the project until the situation has been corrected	2	0	0	1	0	3	**0.400**	2nd
c)	Deregistration	2	1	0	0	0	3	**0.267**	3rd
	others	-	-	-	-	-	-		

$$\text{RII} = \frac{\sum w}{AN} \quad (1)$$

Or

$$\text{RII} = \text{Sum of weights}\left(W1 + W2 + W3 + \ldots\ldots\ldots + W_n\right)/A \times N \quad (2)$$

where w is the weighting given to each factor by the respondent, ranging from 1 to 5 in which "1" is the least important and "5" the most important; A is the highest weight, in this study $A = 5$; N the total number of samples.

Considering disposal as an example, the following is how the formula is used;

$$\sum w = \left[(1\times 0) + (2+0) + (4\times 4) + (5\times 24)\right] = 136 \quad (3)$$

$$A \times N = 5\times 28 = 140 \quad (4)$$

$$\text{RII} = \frac{\sum w}{AN} = \frac{136}{140} = 0.971 \quad (5)$$

The example above is based on the data collected from the field and applied in the formula.

6. Results and Discussion

6.1. Method of Waste Management Analysis from Contractors

From Table 6, waste disposal was found to be the most used method of site waste management having recorded the first ranking at a mean score of 0.971

based on the responses from contractors. The second ranking was reuse at 0.664 followed by waste reduction. On-site segregation was ranked fourth. Recycling ranked least with the mean score of 0.293. Some of the reasons cited to explain the trends in the use of the methods above included:

- Disposal: It is the easiest method, it is cheaper and it is the specified method of waste management in contract documents.
- Reuse: Cost saving and economical.
- Reduce: improved and accurate estimates/measurements.
- On-site segregation: Lack of space on site to perform it and that it is time consuming.
- Prefabrication: Not commonly used method of construction and lack of full knowledge.
- Recycling: lack of machinery and equipment. It is costly.

6.2. Method of Waste Management Analysis from Consultants

Table 7 shows various methods of waste management that are utilised in ZCI as perceived by the consultants. The table gives an illustration in the frequency of responses obtained which in turn enabled the identification of the factor (method of waste management) with the highest frequency for the purpose of ranking them using the Relative Importance Index formula (RII).

From the consultants' feedback, waste disposal was ranked first just like in the contractors' results with the mean score of 0.874. Reuse was ranked second in the order of waste management practice with a mean score of 0.6 as seen in table 7. Data from government's institutions also indicated disposal as the highest ranking with a mean score of 0.867 in terms of the most dominant specification for waste management as indicated in Table 8.

6.3. Familiarity and Experience with the Activities in SWMPs from Contractors

Table 9 and Table 10 shows the results for assessing the feasibility of adopting a Site Waste Management Plan in the ZCI. Table 9 shows the level of experience and familiarity with SWMPs among the respondents from the contractors.

It is clear that the level of familiarity and experience is just about average with a mean score of 0.49. Many respondents could not identify waste contractors nor estimate the amount of waste to be generated. The two ranked 4th and 5th respectively in terms of familiarity. Thus, it can be concluded that most of the contractors in the Zambian Construction Industry do not have full knowledge and understanding of the Site Waste Management Plan. Sensitisation and training on SWMP is required in order to handle construction waste in a more sustainable manner.

6.4. Familiarity and Experience with the Activities in SWMPs from Consultants

Table 10 shows the results on the feasibility of adopting a Site Waste Management Plan in the ZCI as the main issue, from the consultants' perspective. The table presents results on the level of experience and familiarity with SWMPs among the consultant respondents.

The results from the consultants were not different from the contractors. It is clear that the level of familiarity and experience is just about average with a mean score of 0.54, slightly better that the contractors results. Many respondents were not very familiar with forecasting types of waste likely to be generated and estimating the quantity of waste to be generated by the project. The two ranked 4th and 5th respectively in terms of familiarity according to Table 10. It is evident that there is not much less experience and knowledge on SWMPs among the consultants in the Zambian Construction Industry. This in turn requires enhanced awareness campaigns and training programmes on SWMP.

6.5. Challenges in the Adoption of a Site Waste Management Plan in ZCI

In line with the last objective of this research, likely challenges and benefits that would come with the adoption of a SWMP from the contractors' perspective were considered. Table 11 shows the perceived challenges associated with adopting a SWMP from the contractors view being the implementers of the plan.

The findings from Table 11 indicate that the main challenges identified are the lack of experience/training and construction culture/behaviour which ranked first and second in terms of importance rankings respectively. However, these can be overcome by introducing awareness workshops and training programmes on SWMPs and enforcement incentives to all stakeholders which include contractors, consultants and government units such as regulators.

6.6. Benefits in the Adoption of a Site Waste Management Plan in ZCI

Table 12 shows that the highest perceived benefit as shown in the ranking by the relative importance index was environmental benefits, followed by SWMPs providing a formally structured approach to site waste management. Reduced waste to landfills and reduced waste on site/prevention of pollution ranked third and fourth on the list importance of benefits. The results show that contractors acknowledge the benefits of introducing a SWMP which provides a good foundation for introducing a SWMP in the ZCI industry.

6.7. Method of Regulation

Table 13 shows that introducing fines to offending contractors ranked first with an index of 0.667 while stopping the project until the situation is corrected ranked second with deregistration being the least ranked. The results demonstrate regulators willingness and commitment to take steps in ensuring that a SWMP is introduced in a sustainable manner.

7. Research Conclusions

From the literature review, the research findings and analysis the following conclusions were drawn from this research based on the set objectives. Disposal was the most frequently used method of construction site waste management in Zambia based on the sample target areas. This was attributed to the fact that disposal is the method that is commonly specified mode of waste management in the guidelines and contract documents as evidenced in the findings. Further it was concluded that the waste management practices in the ZCI do not fully conform to the waste management hierarchy. All the three categories of respondents indicated that a SWMP would be an effective means to safely manage construction waste in the ZCI. The most notable challenges identified included; Construction culture and behaviour, lack of experience/training and Low financial incentives. The benefits of adopting a SWMP based on the findings included: environmental benefits, reduced waste to landfills, and reduced waste on site and preventing pollution. Other supplementary benefits were that it would provide a formally structured approach to on site waste management and allocation of resources more efficiently. Regulators indicated their willingness to support a SWMP through incentives such as fines for offenders and halting of non-complying projects with deregistration being the last option. The study clearly indicated that there is unsustainable construction waste management practice in the Zambian Construction Industry. Further the practice presents a serious challenge of environmental damage and degradation. The situation can be corrected through training, awareness campaigns commitment incentives and involvement of all stakeholders in the introduction of SWMP as part of sustainable construction waste management in the Zambian Construction Industry.

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