

# Towards Sustainable Construction Waste Minimization and Management in Zambia and Beyond

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**Abstract:** Zambian Construction is one of the fastest growing sectors (increasing at 15.3% pa in 2012) from residential and commercial developments and mining infrastructure. The industry in Zambia, like elsewhere, is composed of many players including designers, contractors, regulators, manufacturers and suppliers of construction materials. However, opportunities for sustainable construction waste minimization and management (WMM) have been minimal.

Most research in developing countries has been targeted on Municipal Waste Management rather than Construction and Demolition (C&D) Waste. C&D Waste is generally in form of masonry units, mortar, timber, glass, steel and plastic and most generation is arises from masonry units and mortar. In the developed countries guidelines do exist, supported by regulation and legislation.

This paper addresses the status on C&D waste management in Zambia as compared to the rest of the world, mainly through literature review, with a view to recommending strategies for sustainable Waste Minimization and Management. As highlighted by several researchers and institutions, worldwide, WMM requires partnerships of strategies, which covers processes over the entire life cycle of construction infrastructure. The paper highlights some of best practices towards sustainable C&D waste minimization and management elsewhere. Finally, recommendations are made on how to achieve best practice in Zambia, sub-region and beyond.

**Keywords:** Municipal Waste, Construction and Demolition waste, design and construction practices

## 1 Introduction

There are many definitions of construction and demolitions (C&D) waste. As highlighted by Osmani et al [1], the European Council Directive 91/156/EEC, defines waste as “any substance or object which the holder discards or intends or is required to discard” (Directive 91/156/EEC [2], Article 1, Letter a). The definition was further expanded as a material “which needed to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project due to damage, excess or non-use or which cannot be used due to non-compliance with the specifications, or which is a by-product of the construction process”.

Waste is a human concept defining a material with no intrinsic worth or value, or a material discarded despite its inherent worth or value. The EPA definition of C&DW as outlined in their annual National Waste Reports is: “...all waste that arises from construction and demolition activities including excavated soil from contaminated sites. Those wastes are listed in Chapter 17 of the European Waste Catalogue (EWC).”

Osman et al [1] identified seven different types of waste: bricks, blocks and mortar (33%); timber (27%); packaging (18%), dry lining (10%); metals (3%); special waste (1%); and other waste 10%. It can be observed that most of the C&D wastage results from masonry units and mortar, possibly due to the high level of manual handling.

Yakkaluru and Naik [2] **categorized C&D waste** by are as follows; *Process Waste*: The waste generates in the process of construction activities, such steel off-cuts, masonry units, concrete and timber; *Demolition Waste*: The waste generates in the demolition activity is called demolition waste, in terms of types, these may be *Natural Waste*: Acceptable level of waste from a construction activity; *Direct Waste*: This is the waste which can be prevented and involves the actual loss, *Indirect Waste*: This is cost waste, distinguished from direct waste by no physical loss of material, and *Consequential waste*: Cost of wasted materials is greater than their value and this additional cost is usually hidden.

Several approaches have been taken in analysing C&D waste, such as those based on efficiency of manufacturing, sources or as a result of flaws in the design and/or procurement/project management and materials handling. Other studies have focussed on assessing barriers to sustainable C&D WMM.

Zou et al [3] through a research (literature review, workshops and interviews) in Australia, identified several barriers to re-use and recycle in construction waste: The top six barriers included; *Policy and governance*: Government policy is not driving recycling; *Quality*: contamination of recyclables due to lack of separation or lack of space for separation; *Cost*: Alternatives to recycling are cheaper – landfill gate prices are too low; *Information*: Lack of information re industry infrastructure; *Knowledge and education*: Lack of knowledge across industry and requirement for training; and *Perception and culture*: C&D material is not considered as a potential resource (except metal).

In order to invest in reduction, re-use and recycling of construction materials, it is important to establish generation and collection rates on C&D Waste. In the developing countries, including Zambia, limited studies have been conducted. Where studies have been conducted, emphasis has mainly been on Municipal Waste rather than Construction Waste. The IFC fact sheets [4] indicate Municipal Waste (MW) generation and collection rates, by region, per capita by region, per capita by income levels around the world and give projections by 2025. It may be noted that the MW collection rates vary from country to country, and has a large bearing on the adverse impacts of C&D waste.

In general, C&D waste may be estimated either in terms of the total cost of a construction, or in term of the floor area for the building. If the later is used, the cost will depend on the type of structural and non structural members. For example a reinforced concrete frame buildings are likely to have different factors than those which could be used for a steel frame building.

Figures 1 indicate disposal rates whilst Tables 1 and 2 show profiles of Urban waste generation worldwide, whilst. It will be observed that Africa has the lowest generation rate whilst OECD has the highest, depicting the lower levels of construction activities.



**Table 1 Waste Generation by Region**

REGION	2012 DATA			PROJECTIONS FOR 2025			
	Total Urban Population (mil)	Urban Waste Generation		Projected Population (millions)		Projected Urban Waste Generation	
		Per capita (kg/capita/d)	Total (tons/d)	Total Population (mil)	Total Urban Population (mil)	Per capita (kg/capita/d)	Total (tons/d)
AFR	261	0.65	169,119	1152	518	0.85	441,840
EAP	777	0.95	738,958	2,124	1,229	1.5	1,865,37
ECA	227	1.1	254	389	239	1.5	354.810
LCR	400	1.1	437,545	681	466	1.6	728,392
MENA	162	1.1	173,545	379	257	1.43	369,320
OECD	729	2.2	1,566,286	1,031	842.2.1	2.1	1,742,417
SAR	426	0.45	192,410	1,938	734	0.77	567,545
<b>Total</b>	12,980	1.2	3,532	252.7	285	1.4	6,069,703

Source: IFC (2012)

**Table 2 MSW Generated in Selected Countries by Income and Region**

COUNTRY	INC	REG	2012 DATA			PROJECTIONS FOR 2025			
			Urban Pop (mil)	Per capita MSW (kg/capita/d)	Total MSW (tons/d)	Total Pop (mil)	Total Urban Pop (mil)	Per capita (kg/capita/d)	Total (tons/d)
<b>Uganda</b>	LI	AFR	3.450	0.34	1,179	54.011	9.713	0.65	<b>6,313</b>
<b>UAE</b>	HIG	MENA	2.526	1.66	4,192	6.268	5.092	2.00	<b>184</b>
<b>UK</b>	HIG	OECD	54.411	1.79	97,342	65.190	59.738	1.85	<b>110,515</b>
<b>USA</b>	HIG	OECD	241.972	2.58	624,700	354.930	305.091	2.3	<b>701,709</b>
<b>Uruguay</b>	UMI	LCR	3.025	0.11	329	3.548	3.333	0.60	<b>2,000</b>
<b>Vannatwa</b>	LMI	EAP	33.430	3.28	110	0.328	0.113	3.00	<b>339</b>
<b>Venezuela, RB</b>	UMI	LCR	22.342	1.14	25,507	35.373	34.059	1.50	<b>51,089</b>
<b>Viet.</b>	LI	EAP	24.001	1.46	35,068	106.357	40.505	1.80	<b>72,909</b>
<b>Zambia</b>	LI	AFR	4.010	0.21	842	16.539	6.862	0.55	<b>3,774</b>
<b>Zimbabwe</b>	LI	AFR	4.478	0.53	2356	15.969	7.539	0.75	<b>5,277</b>

C=Country, IN=Income, REG=Region, Pop=Population

Source: adapted from IFC 2012 Report

Wing-Yan Tam and Lu [5] conducted a study to Construction Waste Management Profiles, Practices, and Performance: A Cross-Jurisdictional Analysis in Four Countries. They argue that there are two generic practices for dealing with C & D waste. From a technical point of view, environmental engineers investigate how “hard” technologies can help manage C & D waste, i.e., through introduction of prefabrication, using metal formwork, and using recycled aggregate for different concrete applications. They further argue that by appreciating the levels of C & D waste the social issue, “soft” economical or managerial measures can be promoted.

They indicated that C&D waste generation per construction GDP (CDW/CGDP) (mt/mUS\$) was a universal benchmark that can be used to compare CWM practices across different jurisdictions. It established that Australia has a range 28.48 - 44.04 (t/mUS\$); Europe between 47.00 and 58.89 (t/mUS\$); Hong Kong has 39.85 - 120.86 (t/mUS\$); and the United Kingdom 34.29 - 51.53 (t/mUS\$). They observed that generally, most countries witnessed a declining trend in terms of waste generation. Further noted that although promotion of “greener” construction industry around the developed world is increasing, the efforts are also linked to the economic profiles of various countries, there is need to share knowledge in the construction industry to improve the waste management effort especially in the developing countries, which have recorded low stable CDW/CGDP.

Abarca Guerrero, L. [6], collected some waste generation rates, shown in Table 3 and developed a construction waste generation model for developing countries, with a case study on Costa Rica. The construction sector in Costa Rica is labour intensive, relying mainly on unskilled workers, trained on site and moving rapidly among construction projects. The determination of generation is complicated but a lot of barriers, as highlighted by other researchers. The construction waste generation model shows that the construction industry in developing countries faces many challenges in order to improve the performance and efficiency of the building process. These challenges are not only as a result of technological aspects, but financial, environmental, socio-cultural and legal aspects also hinder the industry to modernize their practices. Similar findings were obtained while analyzing the factors that influence waste management systems in developing countries.

## **2 Strategies for Sustainable Waste Management**

### **Good WMM Practices worldwide**

IN the EU C&D waste accounts for approximately 25% - 30% of all waste generated in the European Union (EU) and consists of numerous materials, including concrete, bricks, gypsum, wood, glass, metals, plastic, solvents, asbestos and excavated soil, many of which can be recycled.

C&D waste arises from civil and building construction, maintenance and demolition, and maintenance. In some countries materials used for land leveling are regarded as construction and demolition waste.

C&D waste has been identified as a priority waste stream by the EU and high potential for re-use and recycling exist, particularly for derived aggregates from roads, drainage and other construction projects. Technology for the separation and recovery of construction and demolition waste is well established, readily accessible and in general inexpensive.

The Waste Framework Directive (2008/98/EC) provides a framework for moving towards a European recycling society with a high level of resource efficiency. Article 11.2 stipulates that "Member States shall take the necessary measures designed to achieve that by 2020 a minimum of 70% (by weight) of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the List of Wastes shall be prepared for re-use, recycled or undergo other material recovery" (including backfilling operations using waste to substitute other materials).

Despite this effort, the level of recycling and material recovery C&D waste varies in the range (<10% to >90%) across the Union. Separation at source ensures C&D waste does not contain amounts of hazardous wastes, which could pose particular risk to the environment and hamper the recycling effort.

A number of countries have come up with guidelines on waste minimization and management (WMM) to address effects of C&D waste. The Environmental Protection Agency (EPA) has estimated that C&D Waste production rose from 3.7 million tonnes (Mt) in 2001 (EPA, 2003) to a peak of 17.8 Mt in 2007, (EPA, 2009a), with a subsequent decline to just over 3 Mt in 2011 (EPA, 2013).

The UK Waste and Resources Action Programme (WRAP) [7] has identified five key principles that design teams can use during the design process to reduce waste:

1. Design for Waste Efficient Procurement
2. Design for Materials Optimisation
3. Design for Off-Site Construction
4. Design for Reuse and Recycling
5. Design for Deconstruction

The European Community has developed a *Design out Waste* management hierarchy, which involves five steps; prevention, Preparing for re-use, Recycling, Recovery and Disposal. Sustainable management of construction waste can only be tackled by a partnership of interventions from all stakeholders.

Good practice WMM can be applied to all forms of construction projects, regardless of the procurement route adopted. It entails adopting WMM principles at the earliest possible stage, as mandated by the client through procurement provision. The principles should be communicated to all stakeholders; by the design team, contractor, sub-contractors and waste management contractors throughout all project phases – from outline design to project completion, operation, maintenance, and decommissioning.

The NSGH project in Glasgow, for example, was £575 million capital project and the largest NHS construction project in Scotland. Use of a NetWaste Tool, resulted in:

- a 6,500-tonne reduction in construction waste generated throughout the project compared with standard industry practice if all identified actions were to be implemented
- An identified potential cost saving in the avoided cost of wasted materials when compared with standard industry practice.
- A landfill diversion rate of over 90%.

Based on a Sustainability study, for £575 million=US\$875.09million (US\$ 1.5219 to 1 UK £ ([www.gov.uk](http://www.gov.uk), spot rates, HM Revenue and Customs) and average 52.945t /million US\$ (Tan et al), the expected waste, generation rate was 52.945x875.09=46332 t. Thus the reduction in construction waste (6500t) may be estimated to be 14% was generated, compared to industry average in the UK.

Seneviratne et al [8] demonstrated that contractor capacity in Malaysia has a bearing on the waste generation, by determining cement wastage. The study established that upper grade contractors generated less waste compared to their lower grade counterparts. The corresponding cement wastage; for M1 to M5 grade contractors were 5.35%, 6.01%, 5.97%, 13.35% and 24.18%, respectively. This confirmed the research hypothesis that "Construction waste generation is inversely proportional to the capacity of a contractor".

According to the REBRI Guide [9] in New Zealand, C&D waste may represent up to 50% of all waste to landfills in New Zealand and the majority of waste to clean fills or C&D dumps. This implies up to 1.7 million tonnes of C&D waste is sent to landfills every year and similar amounts to clean fills.

The guidelines cover:

1. pre-design and planning
2. concept design
3. detailed design
4. building material and product selection
5. project management
6. after the project is finished

Peddavenkatesu and Naik [2] through their study established causes of C&D waste generation as; Improper storage of cement, construction flaws, improper handling of materials and products (cement, masonry units), unrequired extra works (extra slab thickness, extra filing of columns), and improper planning and procurement.

AJAYI [10] investigated the interrelation of design, procurement and construction strategies for waste minimisation, using a dynamic approach, on construction waste mitigation. The study identified the design stage had the most decisive impacts on construction waste Minimisation. Materials procurement process was a factor in enhancing waste minimisation, the study suggested that during the construction stage, waste reduction could be achieved interventions such as prefabrication and offsite technology,

contractual requirements, maximisation of materials reuse and improved collaboration. The study identified the dynamic interplay between various stake holders suggested that designers could effectively minimize waste through dimensional coordination and standardisation of design in line with standard materials Suppliers.

Mulenga [11] highlighted that several materials of construction, from different sources are available on the Southern African market, and there was need for harmonization of standards in Southern Africa. Standardization is a means by which regional and international agreements, trade and collaboration can be boosted to achieve a sustainable built-environment. ‘Green’ practices and innovation must be encouraged through intelligent standards, codes of practice and specifications, as well as advocacy.

**Barriers and Strategies for Achieving Good Practice**

Zou et al [3] conducted a study on Barriers to building and construction waste reduction, re-use and recycling: A case study of the Australian capital region. The top six barriers identified from research, workshops and interviews included the following:

- Policy and governance:* Government policy is not driving recycling;
- Quality:* contamination of recyclables due to lack of separation or lack of space for separation;
- Cost:* Alternatives to recycling are cheaper – landfill gate prices are too low;
- Information:* Lack of information re industry infrastructure;
- Knowledge and education:* Lack of knowledge across industry and requirement for training; and
- Perception and culture:* C&D material is not considered as a potential resource (except metal).

WRAP [7] has also highlighted the barriers and how to achieve good practice during the construction stage, as presented in Table 3.

**Table 3 Key constraints to achieving good practice**

<b>Key Constraint</b>	<b>Implication</b>	<b>Achieving Good Practice</b>
Lack of a client requirement for Good Practice	No contractual obligation by the Contractor	Client and design team to make contractor realize benefits of Good Practice (cost savings, efficient operations)
Site location	No collection and recycling facilities	Ensure the waste management contractor provides a cost effective collection and recycling facilities
Project type	Fit-out projects offer less opportunities for waste recovery	Identify and focus on those material streams that offer Quick Wins
Space on site	Limit space for waste segregation	Target key waste streams and segregate offsite
Project time scales	Tight schedules tend to overlook good practice	Identify and plan the key material streams offering Quick Wins Implement the good practice based on experience



		Establish partnerships with waste management contractors
Contract variations	Loose Procurement methods lead to increase levels of unplanned wastage.	Set up a dialogue with the client and designers at an early stage Identify areas in the design that are not sufficiently developed and suggest possible waste implications.

Source: Adapted from WRAP, Achieving Good Practice Waste Minimization and Management (WMM), Guidance for Construction Clients, Design Teams and Contractors Practice Waste

### 3 Conclusion and Recommendation

#### Conclusions

Sustainable C&D WMM only achievable if all stage of the construction cycle are addressed, and is essential regardless of degree of mechanization (LBT, INTERMEDIATE or MACHiNe-based).

To benchmark good practice, there is need for conducting studies on C&D waste generation, and disposal. It is said, “**If you can't measure it, you can't improve it.** - *Peter Drucker*”. The majority of studies have been conducted in the developed world, and have tended to target Municipal Waste, rather than C&D waste, hence the need to develop models that can address the developing world. The C&D generation models quantities are based on either the total cost of the construction projects, or the floor space, depending on the type of building.

It has been shown that to address sustainable C&D waste minimization and management requires concerted efforts from all stakeholders, supported by appropriate policies, regulation and enforcement. The developed countries are advanced in this area. Zambia and regional groupings need to develop appropriate standards and codes of practice, to promote trade and regional integration.

#### Recommendations

Zambia and the sub-region need to develop appropriate standards and codes of practice and specifications that will ensure sustainable construction taking into account topical issues such as Climate Change and Green construction principles. Country and regional professional and economic, such as SADC, SATTC and ASANRA should spearhead funding such efforts.

More efforts are required towards sustainable C&D WMM through strong partnerships between education, training, R & D institutions, and the construction industry.

Pro-active efforts and dedicated funding are required to and promote best practices in the construction industry, through policies, legislation, regulation and enforcement, which should also address regional requirements.

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