CONSTRUCTION WASTE MANAGEMENT PRACTICES IN PRIVATE AND PUBLIC PROJECTS IN ABUJA, NIGERIA

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MTECH/SET/2019/9775

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JULY, 2023

ABSTRACT

The construction industry is facing the problem of construction waste generation across the globe, especially in developing countries like Nigeria. This waste generation has a negative impact on the environment, cost, productivity, time, society, and economy of the nation. This research aims to investigate waste management practices in private and public construction projects in Abuja, Nigeria, with a view to improving project performance as well as producing environmentally friendly projects. There is no database of private building projects executed in the study area, which makes the establishment of a population difficult. Therefore, two professionals were purposefully selected from each of the thirty (30) public and thirty (30) private projects visited in the study area. The study utilized closed-ended questionnaires and adopted both descriptive and inferential methods of analysis. Going by the overall ranking of the two categories of construction sites damaged due to transportation with a means score (MIS) of 3.70 was ranked as the most important factors contributing to waste generation on construction sites. The findings revealed construction waste management cannot be effectively carried out due to limited space as the most important challenges faced by waste management practitioners on construction waste sites. It is concluded that proper waste management practices in private and public construction projects, when adhered to, help produce environmentally friendly projects and serve as a guideline for good waste management on sites. The study recommends that professional bodies work with university bodies so as to inculcate sustainable building education into their various academic curricula. Also, construction companies should endeavor to provide adequate training to their workers on waste handling issues.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Construction is an imperative industry that plays a vital role in the socio-economic growth of a country. It provides the necessary infrastructure and physical structure for activities such as commerce, services, and utilities (Khan *et al.,* 2014). Besides that, it also generates employment opportunities and enhances the nation's economy by creating foreign and local investment opportunities (Nor-Solehah, 2015). The construction industry involves different processes and it utilizes huge quantities of resources. The processes have severe impacts on the environment, the processes ranges, from the extraction, processing of raw materials used in construction, the operation of the building, up to the eventual demolition of the structure at the end of its operative life (Gulghane and Khandve, 2015). Construction works are either public or private clients sponsor.

The public sector in the form of government departments and their subsidiaries, not only manage the economy, it set and maintain standards for the construction industry, it also acts directly as a client for construction works such as town halls, governmental offices, schools, hospitals, and public housing (Lu *et al.,* 2020). Owing to the large size of budgets and the complexities involved, the Public sector is indispensable on development of infrastructure projects such as transport, energy, telecommunications, and water owing to the large size of their budgets and complexity involve.

In contrast, the private sector is primarily involved in the development of real estate such as private offices and residential buildings. Although in recent time private sectors is involves in construction projects through Public and Private Partnership (PPP).

The construction industry across the globe is facing problem of construction waste generation, most especially in developing worlds such as Nigeria. This generation of waste has a negative impact on the environment, cost, productivity, time, society, and economy of the industry (Kozlovská and Spiáková, 2013; Marzouk and Azab, 2014; Osmani, 2012). In addition, the level of waste generation may weaken the efficiency, effectiveness, value, and profitability of construction activities. The rate of waste generation has continued to increase, due to population growth, lifestyle choices, consumption, and technological advancement (Asase *et al.*, 2009), and these has strengthened the need to address this environmental concern. While ineffective Waste Management Practice (WMP) at construction site compounded the problem. Waste generation varies from one sector of the economy to another and from country to country.

Poor waste management is a waste contributor and a serious environmental issues. Ineffective waste management practiced at construction site increases the generation of construction waste. The contractors are expected to behave the same under the same set of Construction Waste Management (CWM) public policies regardless of the sector that employs them. The two sectors are expected to perform the same in the formal public policies irrespective of the sector. Although (private and public) Waste streams vary according to the phase of construction, the method and the type of building making it important to adapt waste management practices to suit the specific site and phase of construction. Most wastes are produced on-site through: over-ordering; damage by mishandling materials; off-cuts; inadequate storage of materials; and unnecessary packaging of construction materials.

Similarly, Garba *et al.,* (2016) described material waste as those that contribute no value to the construction project and have been recognised as a major challenge to the industry due to their negative effects.

Waste management is made difficult in the construction due to the unique nature of each project, the hostility and unpredictability of the production environment, and the intense cost and time pressure that characterize many construction projects. Tam (2007), affirmed that private clients involved in private housing and commercial projects tend to produce the highest wastage levels when compared with other types of projects. According to Loosemore *et al.* (2011), there is no performance difference amongst contractors who work for various customer groups. This implies there is no agreement on the level of waste generation between private and public sector.

There are various factors that contribute to the generation of construction waste in construction sites. Various researchers have identified factors that contribute to waste generation. For example, a study conducted in Sri Lanka revealed that ignorant of the flow of activities that generate waste is the one of the factors contributing to waste generation (Zaman and Lehmann, 2011). While Nagapan, *et al.* (2012) in a study carried out in Malaysia, identified five significant factors that constitute construction waste.

Poor site management or supervision, a lack of expertise, insufficient planning and scheduling, flaws and errors in design, and mistakes made during construction were the variables highlighted in the research by (Adeweyu and Otali 2013). Furthermore, rework as a result of work contrary to drawings and specifications is a factor contributing to waste at construction sites. A number of studies have highlighted that construction waste is effectively generated during the whole life cycle of construction project (Kozlovská and Spiáková, 2013; Osmani, 2013), such as planning, design, procurement, and construction phases (Wahab and Lawal, 2011). Furthermore, on construction site, material waste can be caused by a variety of factors, including construction method, attitudes of the construction workforce, materials used, and site conditions.

Several studies (Watuka and Aligula, 2002; Nwokoro and Onukwube, 2011; Zuo and Zhao, 2014), have identified the impacts of material wastage to include pollution, resource depletion, climate change, and energy consumption. Studies identified effects such as time overrun, cost overrun, and a source of dispute (Enshassi *et al.,* 2009; Adewuyi, 2012; Dajadian and Koch, 2014). Therefore, waste management is a vital part of construction manager's activities (Shen *et al.,* 2004), to reduce and repurpose the quantity of waste generated. The intent is to achieve sustainable construction practices through social, environmental, and economic principles that contribute to sustainable development.

The predominant stages in managing waste generation are: storage, collection, transfer, processing, and disposal (Rodgers, 2011). Several approaches may be adopted during each stage to ensure effective management. Although waste generation may be inevitable, management is possible and it may be achieved throughout all construction activities, from design to deconstruction. Similarly, waste management is made difficult in the construction due to the unique nature of each project.

1.2 Statement of the Research Problem

There is an ongoing debate over whether public sector clients perform better than their private counterparts in construction waste management, or vice versa. One may argue that as public clients are subject to higher social and political control, they are less likely to practice illegal dumping and should therefore perform better in construction waste management than private clients. This presumption is partly supported by Wang (2018), who discovered that private clients involved in private housing and private commercial projects tend to produce the highest wastage levels when compared with other types of projects. Poon *et al.* (2013) affirmed that public sector projects have imposed more stringent contractual clauses to reduce waste generation and often provided financial incentives for waste management, while private sector projects emphasize time and cost efficiency. Loosemore *et al.* (2011) asserted that there should be no difference in the performance between contractors working for different types of clients.

It is totally impossible to achieve project completion without waste been generated in construction. Construction waste has been a serious problem due to its increasing environmental impact, time and cost overrun effects and due to significant damage, not only to ecosystems but also to the health and wellbeing of field workers and nearby residents of building sites (Li *et al.,* 2009). The increasing amount of material wastes generated from construction activities is becoming a challenging issue to construction site operators (Ikau *et al.*, 2016). This problem keep on aggravating due to increase in level of construction activities leading to increasing amount of material wastes generated from construction activities and this constitutes a big challenge to construction site operators and stakeholders at large (Idris *et al.,* 2015).

The contractor's failure to follow effective waste management practices resulted in the improper handling of construction trash (Idris *et al.,* 2015). Studies have shown that, depending on the size of the contractor, attitudes and practices toward waste management tend to vary (Idris *et al.,* 2015). The vast majority of contractors don't use waste management techniques. None of the previous studies investigated waste management within the context of public and private projects, most especially in Nigeria, it is against this backdrop that this study assessed the management of construction waste in private and public construction projects in Abuja, Nigeria.

1.3 Research Questions

i. What are the factors contributing to waste generation on construction sites?

ii. What are the level of waste generated in private and public construction project?

iii. What are the challenges of waste management practitioners on construction waste site?

1.4 Aim and Objective

1.4.1 Aim

The aim of this study is to investigate waste management practices in private and public construction projects in Abuja, Nigeria, with a view to suggest strategies to promote environmentally friendly projects.

1.4.2 Objectives of Study

In order to achieve the aim, the objectives are:

i. To assess factors contributing to waste generation on construction sites;
ii. To compare the level of construction waste generated and management strategies in private and public construction project;
iii. To assess the challenges of waste management practitioners on construction waste sites.

1.5 Justification for the Study

Globally, cities generate about 1.3 billion tonnes of solid waste per year and this volume is expected to increase to 2.2 billion tonnes by 2025, according to a 2012 report by the World Bank. Building materials account for about half of the materials used and about half of the solid waste generated worldwide (World Bank, 2012).

The construction industry generates a lot of waste globally and this has a negative influence on the environment (Nor-Solehah and Binti, 2015). Construction waste generation does not only affects the environment but has effects on sustainable development as well as increasing the cost of construction projects. Waste management practices is firm obligations which demand the allocation of resources to meet such obligations.

This study will also point out the disparity in construction waste management practices among the public and private sectors. Finally, the outcome of this would contribute to the body of knowledge in future research in providing s information that can be used for further research.

The outcome of this study will intimate the construction practitioners, with the waste management strategies, that would enhance adequate waste management. It would also prevent environmental problems associated with waste management and reduce financial loss associated with materials waste. In addition it would be of great benefit to construction stakeholders (such as contractors and developers) in both the private and public sectors and it will also assist in achieving the best outcomes from waste management practices.

1.6 Scope of the Study

This research focused on construction waste management practices of medium size firms in private and public construction projects in FCT, Nigeria. Medium size contractors were chosen because they are the ones handling bulk of the ongoing construction projects in Abuja. Abuja is chosen due to massive construction ongoing being the administrative headquarter of Nigeria. The study was quantitatively conducted. This study assessed the factors contributing to waste generation on construction sites, compared the level of waste generated and Construction Waste Management (CWM) strategies in private and public construction project. The challenges of waste management practitioners on construction waste sites were examined in order to suggest strategies for promoting construction waste management in private and public projects in Nigeria.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Public and Private Construction Projects

Construction project is categorize based on the ownership of the project or property. Broadly speaking, construction projects are either public or private, but it can further be broken down into 4 types: private residential projects, private commercial projects, state construction projects and federal construction projects. These categorizations are determined by who owns the property and where the construction project is taking place (Poon *et al.*, 2013). On private projects, a lien provides construction professionals with a security interest in the property itself. If they are not paid, they can file a lien claim and encumber the property, making it difficult for the owner to sell or refinance until the contractor's debt is paid. Public land, whether state or federal, cannot be subjected to a lien claim from a contractor. Instead, payments on these projects are secured by the general contractor's payment bond. The bond essentially takes the place of the property if a construction business is not paid, they can file a bond claim with the surety that provided the GC's bond (Scott, 2021)**.**

2.1.1 Private projects

Private construction projects are projects of every type that are owned, controlled or commissioned by a private party. Private parties include individuals, homeowners, corporations, other business entities, non-profit associations, privately funded schools, hospitals, publicly traded companies, etc. In other words, anything that is not own by the government. Private construction projects come in all different shapes and sizes, and it is useful to look at the character of the work performed to segment private construction into different sub categories (Wang, 2018)**.**

These subcategories would include:

(a) Residential Construction

Whenever construction work is being performed for a single-family residence or a residential facility with (usually) less than 3 or 4 units. If you are working on an apartment complex this would more likely be considered a commercial project instead of a residential project. Similarly, if you are working at a condominium, the work would be residential if upon a single unit, but work on the entire complex or the common elements would more likely be considered commercial (Scott, 2021**).** Mechanics lien laws tend to give extra protection to individual home owners. States sometimes require extra notices (or require specific language in them) in order for a contractor to file a lien against their property.

(b) Commercial Construction

Commercial construction is the construction of any buildings or similar structures for commercial purposes. Commercial construction includes a huge variety of projects including building restaurants, grocery stores, skyscrapers, shopping centers, sports facilities, hospitals, private schools and universities, etc. Industrial construction is a relatively small segment of the construction industry. These projects include power plants, manufacturing plants, solar wind farms, refineries, etc. While termed "industrial construction," it is pretty interchangeable with "commercial construction," since, when it comes to payment, they operate in the same category (Scott, 2021**).**

2.1.2 Public Projects

Pubic projects can be classified as follows:

(a) State Construction Projects

Some people get confused by the term "state" when talking about state construction projects because the term "state" can refer to projects commissioned by a county, city, municipality, government board, public school board or any other state-funded entity. The term "state construction" means, therefore, any government-funded construction that is not "federal" (Poon *et al.*, 2013)**.** State construction projects can take a variety of forms. They can be pretty traditional projects like the construction of a public school or government building (like a court room). These projects can also be pretty sophisticated, such as the construction of a bridge, sewer line, highways, etc (Scott, 2021)**.**

(b) Federal Construction Projects

Federal construction projects are very similar to state projects. Just like state projects they can take on a variety of forms: very simple and traditional, and very complex. And the stuff being constructed can be pretty similar to the stuff constructed by state authority: courthouses, government buildings, flood control projects, etc. The difference between state and federal projects simply depends on who owns or controls the underlying project site. The difference is not which entity funds the project, because federal funds are all over state (and even private) projects. The difference is in who owns and controls the project (Domingo, 2015)**.**

2.1.3 Waste in private and public projects

In construction process waste is generated at different stages. For instance, excessive cement mix processes or concrete materials left after work process is done due to change in design rework and demolition occurred and poor workmanship etc. And all the materials used in the construction activities gets wasted, which in turn increases the cost of the project, reduces the profitability and gives a negative impact to the environment. The type of waste generated from private construction projects such residential and commercial projects can be refer to private construction waste. While the waste generated from state or federal owned projects can be refer to pubic construction waste.

2.2 Construction Waste

Waste in the construction industry has been the subject of several research projects around the world in recent years (Yuan and Shen, 2011). Most of these researches have focused on the environmental damage that results from the generation of material waste (Odusanmi *et al.,* 2012) and others have focused on the industry's discourse addressing efficiency issues such as adaptation of present practice (i.e. the need to design and construct building in different ways, for ease of demolition as well as ease of construction) and the creation and application of new knowledge (i.e. the adoption of new sustainable ideas and concepts) (Osmani, 2012). When considering construction material waste, it is important to define what is meant by the term "construction material waste". Udeaja *et al.* (2013) defined material waste as the difference between materials ordered and those placed for fixing on construction projects.

Osmani (2012) and Udeaja *et al. (*2013) argued that material waste should be defined as any negative activities that generates direct and in-direct cost but do not add any value to the project. In a related issue, contemporary research into the problems and solutions of waste in construction projects suggested that waste can occur at any stage of the construction process from conceptualisation, through to the design, construction and demolition of the construction infrastructure (Osmani, 2012; Udeaja *et al.,* 2013). In a sense, this resonates with Kang *et al*. (2006), who argued that construction waste can be divided into two main categories, namely, waste generated due to design and specification, and waste generated by construction activities. The above studies have shown that the most significant sources of construction waste are those generated during the construction phase (usually stemming from poor storage, protection, and site control; poor or multiple handling; poor quality material; inaccurate or over ordering of materials or leftover; inefficient use of materials; bad stock control; lack of training; damage to materials during deliveries; damage generated by poor co-ordination with other trades and theft and vandalism).

2.3 Classification of Construction Waste

Construction waste can be classified into two different categories, namely physical waste and non-physical waste (Nagapan *et al.*, 2012), as shown in Figure 2.1. However, Udeaja *et al.*, (2013) in classifying waste, argued that there can be unavoidable waste (or natural waste), in which the investment necessary to its reduction is higher than the economy produced; and avoidable waste, where the cost of waste is significantly higher than the cost to prevent it. Jaillon *et al*. (2009) identified that construction waste can be categorised into two major forms, namely, inert materials (i.e. soft and hard inert materials) and non-inert waste.

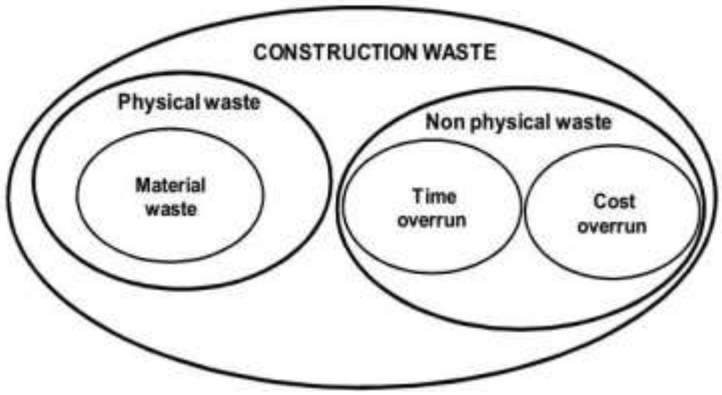

Figure 2.1: Construction waste classification
Source: Nagapan *et al.,* (2012).

2.3.1 Physical Waste

Physical construction waste is denoted as "the waste which originates from construction, renovation and demolition actions including land excavation, civil and building construction, site clearance, roadwork, and building demolition and renovation" (Tareq and Ahmed, 2018). In other words, physical waste is recognized as the debris which can be observed at any construction project. It involves exhaustion of construction materials, since they are irreparably damaged or simply lost. The wastage is usually removed from the construction site to landfills. However, physical waste is classified into three subdivisions: additional material loss, man-hour over production and equipment operational time.

2.3.2 Non-physical Waste

On the contrary, both time and cost overrun are the major forms of non-physical waste which is commonly developed during construction process. Several researchers (Tareq and Ahmed, 2018; Khaleel and Al-Zubaidy, 2018), have reported that both time and cost wastes may cause of material waste generation. For instance, Memon *et al*. (2014) stated that "non-physical waste includes undesired activities, which can cause the physical waste, such as rework, and unnecessary material movements".

2.4 Factors Contributing to Waste Generation on Construction Sites

The construction waste generation has created serious problems, both locally and globally (Tareq and Ahmed, 2018). Construction waste materials are generated in new buildings construction either a residential and non-residential building structures, as well as public works projects, such as roads, bridges and dams (Abbasi and Hanandeh, 2016). Many factors contribute to the generation of material waste. These factors have been grouped by Ekanayake and Ofori (2000) into four categories namely: design; procurement; handling of materials; and operation. They have concluded that most of the causes of waste are due to design issues. This finding has also been reported by a number of other studies (Ekanayake and Ofori, 2004; Innes, 2004; Keys *et al.*, 2000). It is, thus, agreed that the process of waste minimisation must be started at the early stages of the project. A survey conducted by Saunders and Wynn (2004) showed that improper design resulting in excessive cut-offs is one of the major causes of material waste. Therefore, sources of waste revolve around four factors namely: procurement, handling, operation and culture.

Let consider procurement: delivery methods, delivery schedules, purchase of inadequate materials, poor quality of materials, no take back schemes, poor advice from suppliers, and poor supply chain management (Lingard *et al.*, 2000; Domingo, 2015; Ajayi *et al.*, 2017; Holt, 2014; Wambeke *et al.*, 2011, Gündüz, *et al.*, 2013; Aziz,2013). Similarly handling: damages due to transportation, inappropriate handling, poor product knowledge and inappropriate storage (Bekr, 2014; Domingo, 2015; Ajayi *et al.*, 2017; Holt, 2014; Wambeke *et al.*, 2011). Operation: rework, variation and negligence, unskilled labour, time restraint, poor communication, poor coordination between trades and inclement weather (Adewuyi, and Otali 2013; Fadiya *et al.*, 2014; Bekr, 2014; Domingo, 2015). And culture: lack of awareness, lack of incentives, lack of support from senior management and lack of training (Ekanayake and Ofori, 2004; Innes, 2004; Keys *et al.*, 2000). Other factors contributing to waste generation on construction sites were identified by different authors as shown in Table 2.1, including delivery methods, delivery schedules, and the purchase of inadequate materials, poor quality of materials, no take-back schemes, and poor advice from suppliers. Poor supply chain management, transportation damage, improper handling, lack of product knowledge, improper storage, rework, variation, and negligence; unskilled labor; time constraints; poor communication; poor coordination between trades; bad weather; lack of awareness; lack of incentives; lack of support from senior management; and lack of training.

Table 2.1: Summary of Factors Contributing to Waste Generation on Construction Sites

S/No	Factors Contributing to Waste Generation on Construction Sites	Sources
1.	Delivery methods	Lingard *et al.* (2000); Domingo, (2015);
2.	Delivery schedules	Ajayi *et al.* (2017); Holt, (2014); Wambeke *et al.* (2011),
3.	Purchase of inadequate materials	Adewuyi, and Otali (2013); Fadiya *et al.* (2014);
4.	Poor quality of materials	Adewuyi, and Otali (2013); Fadiya *et al.* (2014);
5.	No take back schemes	Adewuyi, and Otali (2013); Fadiya *et al.* (2014);
6.	Poor advice from suppliers	Adewuyi, and Otali (2013); Fadiya *et al.* (2014);
7.	Poor supply chain management	Abbasi and Hanandeh, (2016)
8.	Damages due to transportation,	Tareq and Ahmed, (2018)
9.	Inappropriate handling	Wambeke *et al.* (2011); Gündüz, *et al.* (2013); Aziz (2013)
10	Poor product knowledge	Domingo,(2015); Ajayi *et al.* (2017); Holt, (2014);
11	Inappropriate storage	Ajayi and Oyedele (2018);
12	Rework, variation and negligence	Sasidharani and Jayanthi (2015); Aparna (2017)
13	Unskilled labour	Assem and Karima (2011); Muhammad *et al.* (2020)
14	Time restraint	Dania *et al.* (2007); Hu et al. (2020)
15	Poor communication	Eze *et al.* (2016)
16	Poor coordination between trades	Ajayi and Oyedele (2018);
17	Inclement weather	
18	Lack of awareness,	Ekanayake and Ofori, (2004); Innes, (2004)
19	Lack of incentives,	Keys *et al.* (2000)
20	Lack of support from senior management and	Gündüz, *et al.* (2013); Aziz (2013)
21	Lack of training	Fadiya *et al.* (2014); Bekr, (2014)

2.5 Level of Waste Generated in Private and Public Construction Project in Different Countries of the World

The construction wastes become serious environmental problems in many countries and are becoming more critical recently. Issues related to the public and private construction wastes generation in various countries are discussed below.

(a) Malaysia: Rahmat and Ibrahim (2007) conducted a study in the district of Johor Bharu Tengah, Johor and reported that a total of 46 illegal dumping were found in the investigation, with most of them discovered near the road side corridor. And concluded that forty-two percent of the wastes are actually wastes from construction. A research conducted by Begum and Pereira (2011) found that in the Klang Valley the majority of construction wastes were dumped into private land or illegal dumpsites while only 20% of them were actually disposed in legal landfills. The results also showed that 88% of the construction wastes generated is from residential buildings while 9% from commercial, and 3% from government buildings, all resulting from increased demand for housing and commercial buildings. The largest components of construction wastes are concrete aggregate, and rubbles followed by soil, wood, metals, and roofing materials. In 2013, a research that was conducted in three construction sites found that timber wastes were the dominant waste produced, followed by bricks, packaging wastes, and concrete (Nagapan *et al.*, 201).

In another research, the total wastes generated at two housing project sites was 154.31 m3 and the major wastes consists of timber (49%) (Forster, 2014). Besides that, Masudi *et al.*, (2011) conducted a study intending to quantify the wastage level of several types of material wastes such as timber, concrete, reinforcement bar, tiles, screeds, and plaster. The results showed that the wastage level for major material is up to 10%. They also concluded that awareness among construction players in Malaysia on wastes minimization is still lacking.

(b) Thailand: Inc 2009, the construction industry in Thailand generated an average of 1.1 million tonnes of construction wastes per year between 2002 – 2005 (Kofoworola and Gheewala, 2009).

(c) Indonesia: A research was conducted to determine quantities of construction wastes material. The study indicated that brick and sand wastes were the most wastes on the site which is 12.51% and 11.39% respectively. The cost modelling showed that the range of material wastes cost was between 3.33% to 4.67% of the total material cost (Kareem *et al.,* 2015).

(d) Kuwait: Kareem *et al.* (2015) conducted a research to study the environmental management of construction wastes. The results indicated that construction wastes in Kuwait consist of concrete (30%), bricks (30%), sand (25%), wood (8%), steel (5%), and others (2%). According to statistics and assumptions, the total construction wastes production was estimated to be 1.6 million ton/year (excluding solely earth and sand).

(e) China: In Shenzhen, a research was carried out to investigate the source of construction wastes generation. According to the survey results, concrete, cement, brick, timber, tile, steel, and aluminium wastes are the main wastes source produced at construction sites (Jingkuang and Yousong, 2011). Another research found that Wastes Generation Rate (WGR) ranged from 3.275 to 8.791 kg/m2 while miscellaneous wastes, timber for formwork and false work, and concrete were the three largest components amongst the generated wastes (Lu *et al.,* 2011).

(f) Nigeria: In Nigeria, large volume of waste is generated in construction sites, especially in the Lagos and Abuja metropolis. This is due to its position as

Nigeria's commercial and administrative nerve centre, with it continuing to experience rapid population growth, projected at 6–8% per annum. The composition of this waste comprises concrete, reinforcement steel, plywood, plastics, and other packaging materials. According to Aboginije (2020), waste from concrete, reinforcement, and wood is indicated as the highest waste generated in Nigerian construction projects, generating rates that range between 15–20%, while soil and stones, plastic, and packing materials are the least, with 2–4% generating rates.

2.6 Construction Waste Management

Construction waste, sometimes termed as construction and demolition waste (CandD waste), refers to the solid waste resulting from any construction activities, such as new construction, renovation, and demolition (Roche and Hegarty, 2006; Lu *et al.,* 2019). Construction waste can be generally classified into two generic portions, inert materials and non-inert waste depending on whether it has stable chemical properties (EPD, 1998). Inert materials, such as soil, earth, slurry, rocks and concrete accounts for the vast majority of the construction waste and are suitable to reuse and/or recycle for different purposes, e.g., road formation, land reclamation, and recycled aggregate. The non-inert waste mainly comprises bamboo, plastics, glass, wood, and paper, contaminates the surrounding environment significantly. Therefore, it is not considered for reuse and/or recycling, and it is normally disposed of at landfills (Poon, 2007). Landfilling not only gives rise to negative social-economic impact but also leads to environmental degradation due to anaerobic decay of the materials disposed of and thus the production of carbon dioxide, methane, and leachate (Lu *et al.,* 2015).

It also rapidly exhausts invaluable land resources. In recent decades, vast amounts of construction waste have been generated, which has raised worldwide attention. The need to tackle the construction waste issues gradually fosters the emergence of a distinct discipline, termed as Construction Waste Management (CWM). CWM can be generally guided by the ‘3R' principles, i.e., reduce, reuse, and recycle according to their desirability (Peng *et al.,* 1997). The 3R's highest priority, the reduction has been examined extensively, and substantive measures have been proposed. Such measures generally involve either (1) adopting low waste technologies; (2) reducing waste by design; (3) raising practitioners' attitudes towards waste reduction; (4) developing an effective waste management system; or (5) reducing waste by government legislation (Lu and Yuan, 2010).

Reuse means using the same material in construction more than once, including using the material again for the same function (e.g. formwork in construction) (Ling and Leo, 2000) and new-life reuse for a new function (e.g. using the cut-corner steel bar for shelves; using the stony fraction for road base material) (Dainty and Brooke, 2004). Recycling is considered the final option before disposal. Through recycling, a variety of new materials can be made from construction waste (Bao *et al.,* 2019).

Compared with other Western developed countries, construction waste issues in China are even worse. China is already the world’s largest waste generator and by 2030 its volume of waste is projected to be double America’s volume of Municipal Solid Waste (MSW); nearly 40% of the MSW generated is construction waste, consuming about 40% of natural resources and energy (Wang *et al.,* 2008).

John and Itodo (2013) enlightened the waste minimizations System of reduces, reuse and recycle for the construction waste management in India and the resources from Construction and Demolition (CandD) wastes is yet another benefits for recycle materials for the construction industry of India.

Some wastes are reducing by proper design in early stage. It can possible to minimize some level of CandD waste generated taking proper construction and demolition methods. Manal *et al.* (2014) developed a detailed process for to calculate Construction and Demolition Waste Management (CDWM) approaches by use of Decision Matrix technique. And introduced procedure helps the decision maker such as the CandD contractor or Transportation firms as well as the policy maker on strategic level to take the different influencing factors. Provided data, when planning; changing or implementing CandD waste management systems and approaches. And recommended to make a cost and benefit analysis for each stakeholder in the CDWM system considering weighing the discussed pros and cons of every approach.

Shishir *et al.* (2014) concluded that there are less amount of natural construction resources so it is necessary to reduce CandD waste generation and increase reuse/recycling as the construction industry .in view of international experiences, shortage of aggregate from natural sources being discovered in many parts of the country, so now recycled aggregate can use in constructions processes. The government Municipal waste laws are required to modify and prepare effective plans and strict rules and regulations are important forget out of this problem. And recycled products are important to promote the use.

Nuria *et al.* (2014) described a system based on rules measures which key factor in order to create a 3Rs model Reduce, Reuse, Recycle) for incorporate universities in the CandD waste management for costs savings. By main objectives like restraint of idle wastes, reduction of unnecessary landfills and imitation of recycled CandD wastes and found a broad understanding of the socioeconomic factors implications of waste management over time and policies in the recycled aggregates market and got the goal of 30% CandD waste aggregates in 12 years or less then it. Adewuyi *et al.* (2014) suggested the reusing of the material waste is very good and helpful especially when it will be useful in minimizing demolition of earth's stone crust and green forest cover by aim of reduced mining. By proper reduce, reuse and recycling, these waste materials will not addition of wastes at dumping and disposal sites. Showed that Construction industry can help by encouraging use of recycled concrete stones and bricks. Towards its commitment to protection of environment.

Saadi and Alias (2016) proposed a model for transportation rates and resale value of recyclable materials which makes use of easily available data that can provide an intuitive and simple optimization model for the basic principles of Reduce, Reuse and Recycle into action. Identified the most common causes of waste on site. And identified the advantages of construction waste management. Noraziah *et al.* (2015) conducted a review of existing waste control practices adopted by the responsible parties in Hong Kong and Malaysia in order to minimize the environmental impacts of construction activities. And also embraces the differences and similarities of waste control practices in both countries reviewed. And concluded, there are still many efforts that the Malaysian government can undertake by taking Hong Kong as a role model to tackle the CandD wastes issue. Suggested that there is future research on creating awareness by means of providing effective training on proper waste management method.

And to providing Facilities to support waste management part in recycling need upgrading and improvement. Sumit (2015) slated that natural resources are limited in nature and will be depleted with time. In order to conserve the natural resources, unnecessary wasting of natural resources should be restricted and regulated. Formulation and implementation of proper waste management plan throughout the life cycle of the projects can minimize CandD waste. With an integrated resource management scheme, most of the construction and demolition material can be recycled or reuse and more natural resources can be conserved for our next generations. The success of recycling requires promotion by means of education and information, in addition to judicial rules from the concerned governing body. Harish *et al.* (2015) concluded that it is difficult to manage Construction and Demolition waste in the future. Data should be generated On the basis of Construction and Demolition waste generation on sites. And promote the. Separation of Construction and Demolition waste.

The method for collection of waste should be discovered and modified it suitable for future. Reuse and recycling of waste materials also should be in method thus charges should be applied on generation of Construction and Demolition waste Muhwezi *et al.*, (2012) studied the sources and causes of demolition waste, its environmental effects and suggested the most effective waste minimization methods. Based on the research, construction Waste management plan was evaluating. For effective and proper use of C and D, it necessary that the governing bodies make the implementation practices of this plan regularly. And suggested increase methods of waste minimization. Questionnaire surveys and interviews were conducted to collect professional's opinions on key issues and factors and found factors like better supervision, human resources, knowledge, technology and policy to improve performance of waste construction management.

Nur *et al.* (2016) slated that Improvement in construction waste management among industry stakeholders especially in Malaysia is crucial in ensuring the industry continues to remain relevant. In addition, developing countries like Malaysia are still lack of awareness of the importance of good waste management practices due to the issue of monetary profit that becoming main target to the industry stakeholders. Awareness of industry stakeholders are seems important in order to minimize the gap between developing countries and developed countries. Mbote *et al.* (2016) investigated the most affecting factors behind the waste management system in Northern Cyprus, including a lack of awareness among various industry stockholders about waste reduction and recycling applications, as well as the drawbacks of an ineffective system, and the availability of minimal technology for recycling and reusing materials such as demolition waste recycling, aggregate recycling, and mostly reusing methods for on-site construction. And it was established that the most significant consequences of a lack of knowledge were the reasons for reducing waste materials, which were reported to be a lack of information about the advantages and application. Also, the local governing body should implement effective procedures and promote CandDWM plans among lead contractors, designers, and builders in Northern Cyprus, according to the report.

Thangjam *et al.,* (2015) found that there is a need for a change in building materials management methods in their analysis of a systematic inquiry into the management of construction and construction wastes. Construction site productivity and cost effectiveness will be improved with the use of mechanical material handling. It was discovered that reducing building material waste during the construction process helps to lower project costs. Sawant *et al.* (2016) slate the management of construction waste plays important factor in the cost of project. And it can estimate the cost of construction waste and its impact on cost of project. and also observed that by the generation of construction waste not only the cost of the project gets increased but also high amount of valuable land is got occupied by waste generated in construction industry and it had negative impact on environment. And suggested that by reducing construction waste can help decrease the cost of project. Chen *et al.* (2018) reviewed on current situation of construction waste management in Malaysia construction industry by literature. And invented that have been implemented in the Malaysian construction industry is not serious on the construction waste management. And concluded that, an effective support by the government is needed and providing a most effective policy in managing and reducing construction waste.

The sustainability of resources and environmental problems will not be reduced and eliminated effectively. Elgizawy *et al.*, (2016) tried to provide an integrated solution for developing countries that combines efforts in slum development and zero waste management to get a higher impact on the local area and the national level. By providing job opportunities to the slum dwellers, enhancing the waste management mechanism and reducing the wastes sent to landfills hence moving towards the realization of the zero waste concepts and at the same time fostering the feeling of identity of the slum dwellers and solving the landownership problem. And concluded that Slum development through zero waste concepts is a comprehensive solution to the current slum development problem and waste accumulation problem and should be encouraged by the government.

Wahi *et al.*, (2016) suggested that site construction waste management practices could be important for reduce waste generation. Like strict construction waste management, project drawings, no design changes during construction process. And concluded poor knowledge, poor design documentation and lack of awareness towards waste minimization would increase construction waste generation. Site supervisors should be with the knowledge of waste minimization which could reduce of waste generation on sites.

Construction waste issues are one of the prevailing global problems that require serious attention. The implementation of construction waste management hierarchy can help to handle and manage construction waste generation. Nagapan *et al*. (2012), suggested that this adoption can be integrated into a six stage of waste management hierarchy which includes prevention, minimization, reuse, recycling, recovery, and disposal, as shown in Figure 2.2.

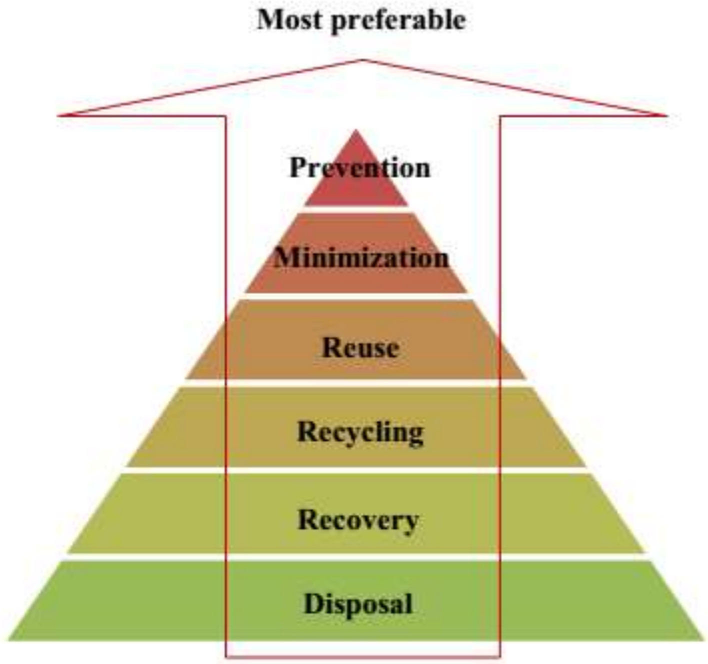

Figure 2.2: Six stage of waste management hierarchy
Source (Adapted from Nagapan *et al*., 2012)

Figure 2.1 shows the six stages of waste management hierarchy that can be adopted to handle the wastes. The stage of the waste management option is ranked based on what is best for the environment. The most preferred way is by preventing or reducing the generation of waste. However, if the waste generation cannot be prevented or reduced, it is recommended to recycle, reuse or recover the wastes as much as possible. But, if wastes are still being produced, then the last option is by disposing the wastes. However, the disposal method is not a preferred option because the role of waste management is to reduce the amount of waste that is discharged into the environment (Nagapan *et al*., 2012). Below is the description for each stage of waste management hierarchy.

2.6.1 Prevention and Minimization

It refers to avoid or reduce producing waste, which is the best way to reduce the impact of waste on the environment (Egan, 1998; Ekanayake and Ofori, 2004; Esin and Cosgun, 2007) and for better economic savings (Al-Hajj and Hamani, 2011). Besides that, avoiding or minimizing from the source in construction project may reduce the amount of waste generation (Kozlovská and Spišáková, 2013), raw material usage, and lessen transportation works (Nagapan *et al*., 2012). In order to prevent or minimize the generation of construction waste, a proper construction waste management approach should be planned before site operations begin. As stated by Lu and Tam (2013), contractors have to prepare a waste management plan as part of the overall environmental management plan, and set out waste reduction targets and programs. They also are advised to set up a good housekeeping practice and a waste management monitoring and audit program, throughout the whole construction processes (Lu and Tam, 2013).

Al-Hajj and Hamani (2011) have suggested four measures for efficient prevention of construction waste on site which are logistics management, supply chain management, modern construction method, and training and incentivizing. In China, the government has taken various actions to tackle the issue of the increasing amount of construction waste generation. These actions include the alteration of the Waste Disposal Ordinance, issuance of a policy paper for a comprehensive year plan to reduce construction waste, launching of a green manager scheme on construction sites, promulgation of a waste reduction framework plan, issuance of a practice note promoting the use of recycled aggregate, implementation of the policy of Waste Management Plan (WMP) at construction sites, commissioning of a pilot concrete recycling plant, and introduction of a charging scheme for the disposal of construction waste (Esin and Cosgun, 2007).

In Malaysia, the implementation of prefabrication and Industrialized Building System (IBS) method in the construction industry was encouraged by the government as a solution to reduce the amount of waste generation (Abbasi and Hanandeh, 2016). The adoption of this method can reduce construction waste generated by as much as 41% to 50%, which is a large amount of reduction (Hassan *et al*., 2012; Begum *et al*., 2010).

Though preventing waste production on site is not possible, we can, however, reduce its amount.

2.6.2 Reuse: It can be defined as using the same material in construction more than once, including using the material again for the same function (e.g., timber formwork in construction). Various countries use this approach to reduce the amount of waste generated before it gets disposed in landfill. In China, the government implements the Construction Waste Disposal Charging Scheme (CWDCS) to encourage 16 contractors to recycle and reuse their construction waste and this scheme has shown a significant reduction even after three years of implementation (Yuan *et al*., 2013). In Germany, a technology of drying distillation and burning is used to handle waste which will separate every kind of material that can be reprocessed cleanly from waste and reused again (Wang et *al.,* 2010). Besides that, some materials such as timber can be reused in the site for several times to avoid the cost of collection and disposal, and the extra cost of virgin material. Broken bricks and concrete can still be reused as a sub-grade of access road to the construction site (Nagapan *et al*., 2012). This approach could help to reduce construction waste at site before it gets disposed.

2.6.3 Recycling: Recycling means separating, collecting, processing, marketing and ultimately using a material that would otherwise have been thrown away (Yeheyis *et al*., 2012). A study has shown that recycling reduces the amount of waste, Green House Gas (GHG) emission, saves energy, and reduces the use of virgin raw material (Pimenteira *et al*., 2005). Various countries have practiced recycling very well in order to reduce the amount of waste. In Denmark, Estonia, Germany, Ireland, and the Netherlands the percentage of recycling rate is more than 80% while in France and Luxembourg the recycling rate percentage is between 40% and 50% (Chakkrit *et al*., 2019). In Finland, the recycling rate of the CandD wasteincreasedto70% as the government imposed garbage tax to 30 euro per tonne in 2005 and planned on increasing the tax further more recently . In Holland, the government had set up a series of laws of restricting dumping of waste and quality control system of forcing recycling. The government also motivated contractors to recycle their waste by granting reward bonus if they used recycled materials in their project. However, the recycling rate of construction waste in Malaysia is still low at 10.5% (Solid Waste and Public Cleansing Management Corporation), due to the lack of awareness among construction players (Masudi *et al*., 2011).

2.6.4 Recovery: It can be defined as the removal of materials or components from the waste stream in a manner to keeps in original form for reuse in the similar form as it was produced. In Germany, the incineration technology has assisted the recovery of metal waste. This recovery tool will cut off until two to three kilograms of harmful 17 heavy metal in one tonne wastes after distillation and burning process. Thus, this method resolves the problem effectively from taking up space at the landfill. Moreover, the gas produced during the handling process is used to generate electricity.

2.6.5 Disposal: The most common disposal of material waste is by landfill (Nagapan *et al*., 2012). This is the final option used for construction waste disposal. However, it is advised to dispose properly at a landfill to alleviate pollution to the surrounding. In Malaysia, the practice of construction waste management is still low as compared to other countries. Most of the waste ends up at landfills. It can be seen in Malaysia that about 261 to 291 landfill sites are in existence (Hussain *et al.*, 2017). Also in Thailand, most of construction waste are buried on site, disposed at landfill or illegally dumped. Reuse and recycle are less frequently practiced since the processing cost exceeds the cost of buying raw material (Manowong, 2012). As a conclusion, it is seen that a waste management hierarchy offer a systematic and efficient waste management strategy which would minimize the generation of waste at different level. A waste management hierarchy should be applied in any construction project. The construction parties involved should try to prevent, reduce, reuse, and recycle the construction waste before it disposes to landfills. The approach will help to reduce negative issues related to environment, social and economy.

2.7 Challenges of waste management practitioners on construction waste sites

The major Factor Affecting Construction Waste Management barriers and motivations for construction waste reported in literature are grouped around six different aspects: financial, institutional, environmental, socio-cultural, technical, and legal (Guerrero *et al.*, 2013).

2.7.1 Financial

Literature suggests that financial obstacles are related to the absence of markets receiving recycled construction products, which jeopardize efforts for construction waste recycling or minimization practices (Yuan *et al.,* 2011). They also mentioned that the sector is reluctant to conduct construction waste management because they perceived that it would result in higher project costs. Moreover, there is an absence of economic penalizing methods for inappropriate waste management, thus hampering construction waste reduction practices. Letelier *et al.,* (2017) found that the workers consider the financial benefits from waste reduction to be inequitably distributed. There is also a perception that waste reduction activities are not cost-effective, efficient, practical, or compatible with core construction activities. They also determined the unwillingness of the workers to separate for recycling or re-using materials that have low economic value or are difficult to reuse.

2.7.2 Institutional

Various authors have suggested that the institutional barriers are related to the fact that designers do not pay attention to waste reduction while designing a building, inconsistencies between different governmental agencies and the lack of coordination among divisions for the application of environmental regulations, the unavailability of waste management procedures (collection, separation, transportation, and disposal of construction waste), lack of managerial commitment and support for the application of better construction practices, absence of norms or performance standards for managing construction waste, and lack of integration of operatives' expertise and experience in waste management processes (Manowong, 2012). In addition, internally, individual responsibilities for waste management is poorly defined, inadequately communicated, and are perceived as irrelevant to operatives (Letelier *et al.,* 2017).

2.7.3 Environmental

Awareness and education have been mentioned as two major topics in relation to environmental barriers for improved construction practices, as well as a lack of sustainable building education at university level, inadequate training by construction workers on waste handling issues, absence of awareness on clients about sustainable housing, and the impact of the activity on the environment. The government and the private sector are more interested in the housing deficit than in environmental issues. Furthermore, healthcare and waste handling training are essential to prevent risks from being exposed to wastes on-site and off-site. When this is provided, stakeholders feel more motivated to voluntarily deal with wastes (Manowong, 2012).There are sufficient technologies available for building with less production of construction waste but there are technical barriers hampering those practices such as insufficient knowledge on how to implement eco-technologies, deficient education for practitioners, and on site operatives on waste reduction practices, which results in a lack of these skills during the construction process (Yuan *et al.,* 2011).

2.7.4 Socio-Cultural

Reported socio cultural barriers are the lack of awareness on the clients and construction workers, which has created a behaviour in which clients have a low demand for sustainable buildings, traditional construction culture, and behaviour, e.g., in China, conventional cast in-situ construction is still the preferable technique against prefabrication (Yuan *et al.*,2011). Furthermore, waste reduction efforts will never be sufficient to completely eliminate waste because it has been accepted as an inevitable by-product of the construction activity. Letelier *et al.* (2017), reported that gender equality has a direct causal effect on construction waste management efforts because women are generally more aware of these issues and can influence stimulating the effectiveness of policies and planning for management of construction waste and pollution. Furthermore, they found that the major practitioners are unlikely to perceive waste management with great importance on projects unless managers make it a priority and provide the necessary supporting facilities, incentives, and resources.

2.7.5 Legal

Construction waste reduction practices are motivated when a legal framework is in place that considers environmental regulations and recycling mandates. Many low- and middle-income economies have created regulations that address the generation of waste by the construction sector. Yuan *et al.* (2011) and Manowong (2012) have reported that legal barriers hampering waste reduction practices are related to insufficient policies in place, if policies exist they are difficult to put into practice, and very often in the absence of enforcement mechanisms

2.7.6 Technical

Some scholars have identified financial, technical, and institutional motivations in relation to construction waste reduction. Cha *et al*. (2009), has indicated that higher disposal cost at landfill site has increased the use of recycled materials. Moreover, he reported that recycled aggregates would have greater acceptance by the public when there are specific guidelines for their use. Companies with a waste management culture within the organization invest in construction waste management by employing waste management workers, purchasing equipment and/or machines for waste minimization, and improving workers' skills. Other technical motivations include: site space for performing waste management, low-waste construction technologies, service experience with recycled materials, development of specifications, and guidelines for the use of recycled materials.

This review of literature will also be assisting addressing the problem of the study. After thorough review of literature on the challenges of waste management practitioners on construction waste sites, the study came up with the findings that are summarized in Tables 2.1

Table 2.2: Summary of challenges of waste management practitioners on construction waste sites

S/No	Challenges of waste management practitioners	Sources
1.	Financial,	Guerrero *et al.* (2013); Yuan *et al.* (2011); Letelier *et al.* (2017)
2.	Institutional,	Guerrero *et al.*, (2013); Manowong, (2012); Letelier *et al.* (2017)
3.	Environmental,	Guerrero *et al.* (2013); Manowong, (2012); Letelier *et al.* (2017)
4.	Socio-cultural	Guerrero *et al.* (2013); Yuan *et al.* (2011); Letelier *et al.* (2017)
5.	Technical,	Guerrero *et al.* (2013); Yuan *et al.* (2011); Letelier *et al.* (2017)
6.	legal	Guerrero *et al.* (2013); Cha *et al.* (2007)

2.8 Strategies for Promoting Construction Waste Management

A shut circle approach to sustainable construction waste management can provide value at every phase of a structure life cycle. Waste management will be discussed according to a ‘cradle to cradle ‘approach. Social or environmental perspective, likewise reduce the problems of settling the gradually increasing solid wastes by partaking better innovation in sustainable waste management (Baek, 2015).

2.8.1 Site waste management plans

Site waste management plan (SWMP) is becoming popular nowadays as a valuable approach for the purpose of assisting construction stakeholders to anticipate the type of construction waste as well as estimate the quantity for making the right decisions in order to manage it (Kabirifar *et al.*, 2020). A waste management plan is required for all public projects and has proved that reuse and recycling can be improved (Tam, 2008). However, the effectiveness of SWMP is limited by site constraints and overhead costs (Poon, 2007). The majority of sites do not have enough areas to carry out on-site sorting, which is labor intensive. The enforcement of SWMP is not common in private projects. It is necessary to provide more sorting facilities and explore the means to reduce overhead costs.

2.8.2 Proper design

Appropriate design can avoid waste generation at the very beginning stage of construction works which includes dimensional coordination and standardization, minimizing the use of temporary works, design for use of recycled materials, avoiding late design modifications, applying low-waste building technologies, backfilling cut and fill by the excavated soils, modeling design information suggested that modeling design information flows could evaluate optimized design solutions (Zhang *et al.* 2012). However, lacking mandatory requirements in the green building assessment tool, designing out waste is not widely practicing in the construction industry (Construction and Industry Council (CIC), 2017). Future research on how to properly designing out waste is necessary.

2.8.3 Deconstruction

Deconstruction, which is also called selective demolition, can effectively facilitate the reuse and recycling of construction waste (Poon, 2007). Deconstruction is carried out reversing the construction processes requiring planned sorting of the demolished materials according to their categories so as to prevent contaminating the recyclable materials such as wood, paper, cardboard, plastic, metal, and concrete aggregates (Li *et al.,* 2014). Expensive manual sorting and insufficient recycling outlets are deterring contractors from carrying out deconstruction. Concurrently the recycling market in Hong Kong is underdeveloped. A mature recycling market is essential to provide more outlets for recyclable items.

2.8.4 Prefabrication and modular construction

Prefabrication can reduce about 52% of construction waste by minimizing on-site wet trade and improving buildability and perform better than conventional construction methods in environmental, economic, and social aspects (CIC, 2017). The Hong Kong Housing Authority has been a pioneer in using prefabrication in building housing estates. However, the implementation of prefabrication is not common in the private sector, and there is room for improvement. Furthermore, prefabrication has some disadvantages including less flexibility with plans and manufacturing, and limitation on transportation (Tam and Tam, 2006).

2.8.5 On-Site and off-site waste sorting

On-site sorting is effective in reducing construction waste and recover valuable materials for reuse and recycling thus reducing disposal costs (Tam and Tam, 2006). However, contractors are reluctant to carry out on-site sorting in spite of high tipping costs due to congested site conditions, tight construction period, high labor demand, expensive operation costs, and lack of recycling outlets. Off-site sorting can be an alternative to promote reuse and recycling since the operating costs can be less expensive than direct disposal at landfills. It is necessary to develop more customized on-site recycling equipment and thriving offsite recycling (Bao *et al.,* 2019). How to select a proper location for off-site construction waste sorting facilities that can reduce transportation costs and prevent noise and dust is an important factor to be considered.

2.8.6 Reduce, reuse and recycling

Most of the construction waste research is largely focused on the “three Rs” principle of waste (reduction, reuse, and recycling), also known as the waste hierarchy. EPD pointed out that “the burden of Hong Kong’s landfills can be reduced through reuse, recovery and recycling” (Ling *et al.,* 2013). Research on reusing waste glass as an aggregate in concrete or additive in cement pastes or mortar have been conducted (Ling *et al.,* 2013; Duan and Poon, 2014; Lu *et al.,* 2017). Though recycling technologies have been developed in recent years, how to promote the use of recycled products is still an issue to be solved. In addition, changing an individual’s recycling attitude and behavior is of utmost importance in achieving sustainable construction waste reduction and management (Mak *et al.,* 2019).

2.8.7 Circular construction

Circular construction is based on the concept of a circular economy model, which tries to keep the products and materials “in flow” by means of effective reuse strategies, thus reducing the use of virgin materials and negative environmental impacts (Kirchherr *et al.,* 2017). This can be accomplished using smart design and circular value chains, which is crucial for a sector to reduce both its waste and the amount of virgin resources used (Ghaffar *et al.,* 2020). Transition to a circular construction involves changes in value chains, from building design, from new professional behavior to new ways of turning waste into a resource. It is necessary to promote construction waste management guidelines in order to "contribute to resource efficiency and enable the transition from a Linear to a Circular Economy" (Taboada *et al.*, 2020).

2.8.8 Zero waste approach

Authorities need to look for alternative waste management systems due to the lack of landfill sites in urban areas. Zero waste (ZW), which is a perceptive system of waste management, has been introduced as an alternative solution for waste problems in recent decades in many cities such as San Francisco, Vancouver, and Adelaide (Zaman, 2015). ZW concept motivates sustainable consumption and production, optimization of resource recovery and recycling, and prevents wastes from incineration and landfilling (Zaman, 2015).

Furthermore, a shut circle approach to sustainable construction waste management can provide value at every phase of a structure life cycle. Waste management will be discussed according to a 'cradle to cradle 'approach. Social or environmental perspective, likewise reduce the problems of settling the gradually increasing solid wastes by partaking better innovation in sustainable waste management (Baek, 2015). The phases are discussed thus:

Stage 1: Objective

Developing the waste management plan and setting the waste management policy at an early stage is essential (Akadiri *et al.*, 2012). In connection to this, the prerequisite for good practice in construction waste management should be introduced at the outset of a project. Said (2018), Proactive waste management plans begin with setting specific objectives by the project owner/client, which should be understood by the project team.

The main objectives in achieving the effective waste management plan must be clear and ought to be incorporated in the project brief by the owner/client.

Stage 2: Planning, Design, And Procurement

The prerequisite set by the client/owner will create a key opportunity for the project team to consider and implement the waste minimization plan (Said, 2018). The project team must be able to deliver what is stated in the project brief. An overall methodology to achieve waste minimization begins during programming and planning. Involvement of the project team at the early phase is crucial in ensuring that the waste management plan can be sustained throughout the building life cycle (Elizar, 2019).

Stage 3: Construction

According to Said (2018), the construction phase of a project will produce the greatest impact to minimising waste produced. The waste management plan developed during the early phase must be adopted on site. Policies related to waste management on site include monitoring and record keeping of wastes leaving the site, which must be formulated and reviewed periodically considering the developments during construction. Designated locations where wastes are dumped in separate compartments enable recycling because fewer efforts are needed to separate wastes when these are indiscriminately dumped (Akadiri *et al.,* 2012). Contractors should be encouraged to develop and propose new methods of construction to reduce the production of waste. Meetings and reports regarding waste management and minimisation on site should be held every week or every month, depending on the levels of involvement (Martos *et al.,* 2016).

The contractor alone is involved; the contractor and the consultant are involved; or all parties involved in the project.

Stage 4: Occupancy

Developing the waste management plan and setting the waste management policy at an early stage is essential (Akadiri *et al.*, 2012). In connection to this, the prerequisite for good practice in construction waste management should be introduced at the outset of a project. Proactive waste management plans begin with setting specific objectives by the project owner/client, which should be understood by the project team (Said, 2018). The main objectives in achieving the effective waste management plan must be clear and ought to be incorporated in the project brief by the owner/client Management of solid waste generated during occupancy ought to emphasize more on environmental solutions to achieve and maintain long-term sustainability goals that cover occupancy (Martos *et al.*, 2016). The project team should design the building with efficient waste management systems based on building type, geography, occupancy and other special circumstances of each individual building and its occupants. Currently, several green rating tools, for example as Green Building Index (GBI), Green RE, Malaysia Carbon Reduction and Environmental Sustainability Tool (My CREST), can be used as a reference in managing waste during occupancy (Ajayi *et al.*, 2017).

Stage 5: Operation and Maintenance

Long-term optimization inactivity and maintenance of the finished building is an important part of the waste management plan (Onuoha *et al.*, 2018). However, the waste management plan developed at the design, the stage should be adequate with the waste management plan execution.

Stage 6: Renovation and Demolition

Potential waste that generated during renovation and demolition ought to be considered at the beginning stage. Such consideration should include proper management based on the aims to maximise the potential usage and profit. Identifying opportunities and actions that will divert waste materials from disposal are important (Ng and Kenley, 2018). In this way, a waste diversion plan should be discussed among professionals at the planning stage, which should cover all the possibilities of waste.

2.9 Performance of Public and Private Sectors on Construction Waste Management Performance.

Public clients have a large pool of projects, which allow some of the construction waste generated from one project to be reused in another (e.g. for backfilling). Conversely, private clients, as various individual profit centers, have higher cost to search for the CW demand and supply information. There are different resource allocations as a result of higher social scrutiny and closer monitoring. Public projects receive higher social scrutiny in construction waste management. Public projects show leadership in environmental management while in private projects, efficiency of materializing the physical project is the business.

Tam (2007), affirmed that private clients involved in private housing and private commercial projects tend to produce the highest wastage levels when compared with other types of projects. Poon *et al.* (2013) also concluded that public sector projects in Hong Kong have imposed more stringent contractual clauses to reduce waste generation and often provided financial incentives for waste reduction; while private sector projects emphasize time and cost efficiency.

Although, Lai *et al*. (2008), there should be no difference in the performance between contractors working for different types of clients. However, the presumption of the difference in CWM performance between public and private sector client-contractor relationships has rarely been tested by empirical studies in the study area. Researchers have attached their attentions to Key performance indicator KPIs) in benchmarking performance of Construction waste management CWM.

For example, Lu *et al.* (2011) measured the success of construction projects through benchmarking the performance with the identified KPIs. Lu *et al.* (2011) produced a benchmarking model based on financial KPIs for construction companies to benchmark and evaluate their business performance at the corporate level in the UK. Oyedele *et al.*, (2013) tried to benchmark the performance assessment of the construction industry by integrating KPIs and data development analysis. More frequently, benchmarking with KPIs also exists in pursuing the success of CWM. Through studying the construction waste generated in a number of hotel projects, Oyedele *et al.*, (2013) found that the benchmarks in existing CWM legislation need to be amended. In measuring waste management performance in the construction industry, waste generation rates (WGRs) are usually replaceable by the KPIs.

It has become the tide that construction industry measures performance of CWM with various data collection approaches by focusing on different KPIs, mainly found expressions in waste amount and WGRs. At early time, the method is to quantify construction waste amount, and digging out the causes of construction waste generation (Bossink and Brouwers, 1996). Poon *et al.* (2004) also quantified waste amount and found the major causes of waste materials were improper preparation, handling, misuse, and incorrect processing. There are certain existing studies using WGRs as the KPIs for measuring the performance of CWM of individual construction projects. To this end, WGRs becomes the KPI of CWM in this study.

Odusanmi *et al.* (2012) examined waste management in Brazil through estimating WGRs, which were waste percentage of purchased materials by weight. Poon *et al.* (2004) measured the WGR with the volume of waste generated per gross floor area (GFA), which is probably the most frequently used KPI in the literature. WGR is also regarded as an important indicator for successful implementation of an integrated construction waste management plan. In previous studies, diversified research methods were adopted to acquire the data to measure WGRs. Furthermore, researchers adopted the neural network method to measure the WGRs for the factory and residential buildings in Taiwan. Interviewing waste manager is also a method for collecting data for calculating WGRs of some projects (Tam, 2007).

Lu *et al.* (2011) examined the waste management effectiveness in a typical city, Shenzhen China by focusing on WGRs of different materials from several construction sites. Visual inspection, tape measurement, and truckload records were used in the study of Poon *et al.* (2004). However, these existing studies usually investigate WGRs with a small scale of data, which therefore cannot identify common rules and generalize their findings to other cases. With the help of convenient data collection and large record, big data and data mining are becoming possible to advance the research on WGRs.

2.10 Measures of Construction Waste Management (CWM) Performance

Waste generation rate (WGR) is widely used to measure performance. WGR can be calculated by dividing the waste in volume (m^3) or quantity (tons) by either the amount of materials purchased, or the amount required by the design, or per m^2 of gross floor area (GFA) (Odusanmi *et al.,* 2012). Methodologies adopted for data for estimating WGRs are diverse and typically include: direct observation (Poon *et al.,* 2001); comparing contractors' records; questionnaire and telephone survey; sorting and weighing the waste materials on site (Bossink and Brouwers, 1996); collecting data through consultation with construction company employees (Treloar *et al.,* 2003; Tam, 2007); and tape measurement and truck load records (Poon et al., 2001, 2004). There are two prevailing approaches: classifying waste materials into different categories, or treating them as a whole. Many studies (Bossink and Brouwers, 1996; Treloar *et al.,* 2003) investigated WGRs by differentiating material waste, while others (Poon et al., 2004) investigated

CandD waste by treating the waste stream as a whole. All the studies derived a general rate such as volume (m^3) or quantity (tons) of waste generated per m^2 of GFA.

WGR indicator:

WGR=Waste quantity/contract sum (ton/Naira)

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

According to Kothari (2008) research design is the conceptual structure within which research is conducted. It constitutes the blueprint for the collection, measurement, and analysis of data. Broadly defined, research design means all the issues involved in planning and executing a research project from identifying the problem through to reporting and publishing the results (Ogwueleka, 2009). Research design could also be seen to relate two views which is the general idea of design as situating the researcher in the empirical world and also connecting research questions to data (Del-Rio-merino *et al.,* 2009). Research design tends to accommodate quantitative approach and places the researcher in the empirical world thereby connecting the research questions to data (Ogwueleka, 2009). According to Bryman (2008) a research design provides a framework for collection and the data analysis.

This research is designed to assess construction waste management practices in private and public projects in Abuja, Nigeria. Using quantitative research design approach. The data required for this study was from primary units. The collected data was analysed using to descriptive and inferential statistics via SPSS.

3.2 Target Population

This study data was collected from construction practitioners (such as project manager, site managers, and supervisors) working in government financed projects and selected private developer's projects sites in Abuja. This study area was chosen because it is the capital city of Nigeria where a reasonable number of construction activities take place. Which leads to constant generation of waste at the various construction sites. There is no data base of private building projects executed in the study area which made establishment of population difficult. In this study, two professionals each were purposively selected from each of the Thirty (30) public and 30 private construction projects visited in the study area.

3.3 Sample Size

There are several approaches for determining the number of participants or observation in a study. The study adopted fraction or percentage of population approach to determine professionals met at site during the field survey. Therefore, 2 professionals each from 30 public and private construction projects domiciled in Abuja were sampled this amount to a total of 120 respondents in the study area as shown in Table 3.1 and Table 3.2.

Table 3.1: Distribution of Respondents

Sn	Construction practitioners	Professionals
1	Public	60
2	Private	60
3	**Total**	**120**

Table 3.2: Sample size

Position of respondent	Number of respondents
Project manager	70
Site manager	48
Supervisor	2
Total	**120**

3.4 Sampling Techniques

Sampling technique is a process of selecting elements that constitutes the population (Kothari, 2008). According to Saunders *et al.* (2009) there are two major types of sampling designs: probability and non-probability sampling. In probability sampling, elements of the population have some known chance or probability of being selected as sample subjects, while in non-probability sampling, the elements do not have a known chance of being selected as subjects. Stratified sampling is a probability sampling technique which ensures that the resulting sample of a study is distributed in the same way as the population in terms of the stratifying criterion (Bryman, 2008). Purposive sampling (judgement or selective) is a non - probability sampling technique in which a researcher relies on his or her own judgement when choosing members of population to participate in the study (Saunders *et al*., 2009). Due to the lack of database of participants of waste management practices in private and public projects in Abuja Snow ball sampling technique was adopted in selecting the project sites for the study and for selecting purposive sampling was used in selecting 2 professionals from each construction sites visited.

3.5 Method of Data Collection

This study data was obtained from primary source via the use of a well-structured questionnaire developed based on the research objectives namely: the factors contributing to waste generation on construction sites, level of waste generated in private and public construction project, the challenges of WMP on construction sites in order to suggest strategies for promoting construction waste management in private and public projects. All the 120 questionnaire administered were retrieved and analysis which implies 100% response rate.

3.6 Questionnaire Design

The questionnaire was designed based on the research objectives. The questionnaire was divided into five sections. Section “A” contains information on the respondent and the project handled by the organization. The other sections relate to a particular research objective. Section “B” relates to factors contributing to waste generation on construction sites. The questionnaires were designed on 5 points Likert scale to sample the opinions construction industry personnel. Section C, relates to the volume of waste generated construction sites. Section D, deals with challenges of waste management practitioners on construction waste sites and Section E is on the Practices for promoting construction waste management in private and public projects.

3.7 Method of Data Analysis

The statistical tools adopted was descriptive and inferential statistics.

Objectives 1, This study was analysed using descriptive statistics Mean Item Score (MIS) was employed to analysed factors contributing to waste generation on construction sites.

Objective 2, was analysed using inferential statistics through the Chi-Square and cross tabulation to compare the level of waste generated in private and public construction project

Objective 3. Descriptive statistics (Mean Item Score) was used to assess the challenges of waste management practitioners on construction sites based on a 5 point Likert scale.

3.7.1 Mean Score

The mean score is an average value of the respondents' answers to a set of questions linked to specified scale. The mean score (MS) for each of the variables in the research instrument, was determined using the formula below:

$$\text{Mean Score} = \frac{5n5 + 4n4 + 3n3 + 2n2 + 1n1}{n5+n4+n3+n2+n1} \qquad 3.1$$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Demographics of Respondents

This section presents the demographic analysis of the participant's information thus:

4.1.1 Type of project

Table 4.1 shows the category of projects in the study area.

Table 4.1: Type of project

Type of project	Frequency	Percent
Private	60	50.0
Public	60	50.0
Total	**120**	**100.0**

The findings revealed that 50.0% of the projects identified were owned by the private sector, while 50.0% of the projects were owned by the public sector.

4.1.2 Status of respondents Surveyed

From the survey carried out on 120 respondents and presented in Table 4.2.

Table 4.2: Position of respondents

Position of respondent	Frequency	Percent
Project manager	70	58.0
Site manager	48	40.0
Supervisor	2	2.0
Total	**120**	**100.0**

Seventy (70) of the respondents were project managers, 48 were site managers, and the remaining two were supervisors.

4.1.3 Educational qualification of respondents

Table 4.3 presents educational qualifications of respondents from the survey.

Table 4.3: Educational qualification of respondents

Educational qualification of respondents	Frequency	Percent
HND/B.Sc	77	64.0
Mtech/M.Sc	43	36.0
Total	**120**	**100.0**

The findings revealed that 64% of respondents had HND/BSc, while 36% had MSc and Mtech. Therefore, the respondents are having adequately knowledgeable on waste management.

4.1.4 Work experience of respondents

Table 4.4 shows that the majority (70%) of the respondents had 5–15 years of experience, while 30% of the respondents had 16–25 years of worling experience.

Table 4.4: Work experience of respondents

Work experience of respondent	**Frequency**	**Percent**
5 yrs – 15 yrs	84	70.0
16 yrs – 25 yrs	36	30.0
Total	**120**	**100.0**

4.2 Factors Contributing to Waste Generation on Construction Sites

This section presents analysis of objective one which is factors contributing to waste generation on construction sites. Table 4.5 reveals the respondent’s perception of factors contributing to waste generation on both public and private construction sites.

Table 4.5: Factors Contributing to Waste Generation on Construction Sites

SN	Factors Contributing to Waste Generation	Overall		Public		Private	
		MIS	**Rank**	**MIS**	**Rank**	**MIS**	**Rank**
1	Damages due to transportation,	3.70	1st	3.69	1st	3.70	2nd
2	Rework, variation and negligence	3.62	2nd	3.23	14th	4.00	1st
3	Inappropriate storage	3.56	3rd	3.43	7th	3.69	3rd
4	Inappropriate handling	3.55	4th	3.54	4th	3.57	7th
5	Poor product knowledge	3.49	5th	3.58	3rd	3.40	11th
6	Poor quality of materials	3.49	5th	3.38	10th	3.60	6th
7	Lack of awareness,	3.48	7th	3.48	5th	3.48	8th
8	Delivery methods	3.42	8th	3.40	8th	3.45	10th
9	unskilled labour	3.42	8th	3.22	15th	3.62	5th
10	Lack of training	3.38	10th	3.27	12th	3.48	8th
11	Inappropriate handling	3.35	11th	3.04	17th	3.65	4th
12	Lack of support from senior management and	3.23	12th	3.25	13th	3.20	13th
13	Poor communication	3.22	13th	3.45	6th	3.00	15th
14	No take back schemes	3.09	14th	3.39	9th	2.80	16th
15	Time restraint	3.09	14th	3.69	1st	2.70	19th
16	Lack of incentives,	3.07	16th	3.35	11th	2.80	16th
17	Delivery schedules	3.06	17th	2.98	18th	3.15	14th
18	Poor supply chain management	3.04	18th	2.78	20th	3.30	12th
19	Poor advice from suppliers	2.78	19th	2.85	19th	2.70	19th
20	Purchase of inadequate materials	2.78	19th	3.06	16th	2.50	20th

Going by the overall ranking of the two categories of construction sites damaged due to transportation, with a means score (MIS) of 3.70 was ranked 1st. This factor was also ranked 1st by expert from public construction sites with a MIS of 3.69 and 2nd with an MIS of 3.70 at private construction sites, Rework, variation, and negligence were ranked

2nd with an MIS of 3.62. The same factor was ranked 14th at public construction sites, with an MIS of 3.23, while expert from private construction sites ranked it 1st, with an MIS of 4.00. Inappropriate storage was ranked 3rd with a MIS of 3.56 going by the overall ranking of the two categories of construction sites. This factor was also ranked seventh at public construction sites, with an MIS of 3.43, and third at private construction sites, with an MIS of 3.69. Inappropriate handling was ranked 4th overall, with a MIS of 3.55. Public construction sites ranked it 4th with MIS 3.54, while private construction sites ranked it 7th with MIS 3.57. Poor product knowledge and poor quality of materials had an overall ranking of 5th with MIS 3.49 and 3.49, respectively. Public construction sites ranked it 3rd and 10th with MIS 3.58 and 3.36; private construction sites ranked it 11th and 6th with MIS 3.50 and 3.60, respectively.

The least ranked factors contributing to waste generation in both public and private construction sites were the purchase of inadequate materials and poor advice from suppliers, with an overall ranking of 19th and 19th with an MIS of 2.78 and 2.78, respectively. This factor was also ranked 16th and 19th with MIS 3.06 and 2.85 at public construction sites, and 20th and 19th with MIS 2.50 and 2.70 at private construction sites.

4.3 Level of Waste Generated in Private and Public Construction Project

Objective 2 of this study is thus presents in this sections.

4.3.1 Average volume of waste generated per day per project

Table 4.6 shows the average volume of waste generated per day per project in tonnes at both private and public construction sites in Abuja.

Table 4.6: Average Volume of Waste generated Per Day Per Project

SN	Type of waste	Private (tonnes)	Public (toones)
1	timber,	1-5 tonnes	> 5 tonnes
2	concrete,	< 1 ton	1-5 toon
3	tiles,	1-5 tonnes	1-5 toon
4	screeds,	< 1 ton	< 1 ton
5	reinforcement bar,	> 5 tonnes	> 5 tonnes
6	plywood,	1-5 tonnes	> 5 tonnes
7	Plastics	< 1 ton	< 1 ton
8	packaging materials	< 1 ton	< 1 ton

The findings revealed that in private construction sites: an average of 1–5 tonnes of timber waste were generated, less than 1 tonne of concrete waste were generated, 1–5 tonnes of tiles waste were generated, less than 1 tonne of screeds waste were generated, more than 5 tonnes of reinforcement bar waste were generated, 1–5 tonnes of plied wood waste were generated, and less than a tonne of plastics and packaging materials were generated per day and per project. While more than 5 tonnes of timber waste were generated, 1 to 5 tonnes of concrete waste were generated, 1 to 5 tonnes of tile waste too were generated, less than 1 tonnes of screed waste were generated, more than 5 tonnes of reinforcement bar waste were generated, more than 5 tonnes of plied wood waste generated, and less than a tonne of plastics and packaging materials were generated per day and per project at Abuja public construction sites.

Table 4.7: Chi-Square Tests showing difference between the levels of waste generated

Chi-Square Tests	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.833[a]	2	.400
Likelihood Ratio	1.843	2	.398
Linear-by-Linear Association	.709	1	.400
N of Valid Cases	**120**		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 3.68.

Table 4.7 shows the difference between the levels of waste generated in private and public construction projects. The waste generated by both private and public were measured as nominal data. The output of the Chi-square analyses revealed that the Pearson Chi-square statistic (f) = 1.833a p-value = 0.400 ($p < 0.05$). The output revealed that the variables are dependent, thus providing enough evidence to infer that there is a significant difference between the level of waste generated in private and public construction projects.

Table 4.8: Volume of Waste Generated Based on the Type of Projects

Cross tabulation			Volume of waste			Total
			Large	**Moderate**	**Low**	
Type of projects	Private	Count	4	29	27	60
		% within Type of projects	7.4%	48.1%	44.4%	100.0%
	Public	Count	5	21	34	46
		% within Type of projects	8.7%	34.8%	56.5%	100.0%
Total		Count	9	50	61	120
		% within Type of projects	8.0%	42.0%	50.0%	100.0%

The cross-tabulation presents in Table 4.8 supports the outcome of the Chi-square test and buttresses the situation in the study areas. Table 4.8 reveals that, 7.4 percent of private projects surveyed generated a large volume of waste, while 48.1% of private projects surveyed generated a moderate volume of waste, and 44.4 percent of private projects in the study area generated a low volume of waste. Similarly, 8.7% of public projects generated surveyed a large volume of waste, 34.8% of public projects surveyed generated a moderate volume of waste, and 56.5 percent of public projects surveyed generated a low volume of waste.

4.4 Challenges of Waste Management Practitioners on Construction Waste Sites

This section of the present analysis carried out in pursuance of objective three. Which was the identification of the challenges faced by waste management practitioners on construction waste sites. The challenges of waste management practitioners on construction waste sites were gauged using mean score analysis.

Table 4.9: Challenges of Waste Management Practitioners on Construction Waste Sites

SN	Challenges	Overall		Public		Private	
		MIS	Rank	MIS	Rank	MIS	Rank
1	Construction waste management cannot be effectively carried out due to limited space	4.54	1st	4.38	6th	4.70	1st
2	Poor skills in construction practices of on-site operatives	4.54	1st	4.44	3rd	4.65	2nd
3	Lack of sustainable building education at university level	4.50	3rd	4.53	2nd	4.48	4th
4	Insufficient regulation support	4.45	4th	4.38	5th	4.53	3rd
5	A belief that waste management efforts will never be sufficient to completely eliminate	4.43	5th	4.67	1st	4.20	7th
6	Lack of available information regarding the requirements of environmental norms	4.37	6th	4.44	4th	4.30	5th
7	Traditional construction culture and behaviour	4.19	7th	4.28	7th	4.10	8th

8	Inadequate training of construction workers on waste handling issues	4.12	8th	4.00	7th	4.24	6th
9	Insufficient knowledge on how to implement eco-technologies	4.00	9th	4.00	8th	4.00	9th
10	Deficiency of environmental regulations	3.88	10th	3.87	9th	3.90	10th
11	Insufficient gender diversity recognition by the sector	3.81	11th	3.79	10th	3.84	11th
12	Existing regulations are difficult to operate in practice	3.76	12th	3.83	11th	3.70	12th
13	Lack of awareness on clients about sustainable housing	3.74	13th	3.84	12th	3.65	14th
14	Insufficient environmental awareness by the industry, political decision makers,	3.72	14th	3.79	13th	3.65	14th
15	Low demand by clients for sustainable buildings	3.67	15th	3.75	14th	3.60	16th
16	Attention by government and private sector on housing deficit than on environmental issues	3.67	15th	3.67	14th	3.68	13th
17	Lack of enforcement of construction and waste management policies and plans	3.60	17th	3.70	16th	3.60	17th
18	Absence of healthcare and waste handling training for workers	3.50	18th	3.50	18th	3.50	18th

The result of the findings from the field survey on the challenges faced by waste management practitioners on construction waste sites, going by the overall ranking of the two categories as shown in Table 4.9, construction waste management cannot be effectively carried out due to limited space, the with a means score (MIS) of 4.54 was ranked first. This factor was also ranked first by experts from private construction sites with a MIS of 4/70 and sixth with an MIS of 4.38 at public construction sites. Poor skills in construction practices by on-site operatives were ranked first with an MIS of 4.54. The same factor was ranked third at public construction sites, with an MIS of 4.44, while experts from private construction sites ranked it second, with an MIS of 4.65. According to the overall ranking of the two categories of construction sites, a lack of sustainable building education at the university level was ranked third with a MIS of 4.50. This factor was also ranked 2nd at public construction sites, with an MIS of 4.53, and 4th at private construction sites, with an MIS of 4.48. Insufficient regulatory support was ranked 4th overall with a MIS of 4.45. Public construction sites ranked it 5th with MIS 4.38, while private construction sites ranked it 3rd with MIS 4.53. A belief that waste management efforts will never be sufficient to completely eliminate waste had an overall ranking of 5th with MIS 4.43. Public construction sites ranked it first with MIS 4.67; private construction sites ranked it 7th with MIS 4.20.

4.6 Strategies for Promoting Construction Waste Management in Private and Public Projects in Nigeria

This section reports presents analysis in pursuance of objective four as formulated in Chapter One. The strategies for promoting construction waste management in private and public projects in Nigeria.

Table 4.10: Strategies for Promoting Construction Waste Management

Strategies for promoting construction waste management	Mean Score	Rank
Reduce, Reuse and Recycling	4.76	1st
Site Waste Management Plans	4.68	2nd
Proper Design	4.60	3rd
Deconstruction	4.16	4th
Zero Waste Approach	4.12	5th
Circular Construction	4.12	6th
On-Site and Off-Site Waste Sorting	4.02	7th
Prefabrication and Modular Construction	3.96	8th

The strategy focuses on eliminating challenges to waste management. A The detailed breakdown of the components of the strategy is presented in Table 4.10, in order of the level of importance attached to them by the construction professionals that were surveyed (indicated by Mean Scores).

4.7 Discussion of Results

The study classified factors contributing to waste generation on construction sites into four categories: procurement, handing, operation, and cultural factors. Damages due to transportation (MIS = 3.70) was identified as the most important overall factor contributing to waste generation on construction sites. This was followed by rework, variation, and negligence (MIS = 3.62). This study finding aligned with the studies of Bekr (2014) and Wambeke *et al.* (2011), were revealed that sources of waste revolve around the following handling factors: damage due to transportation, inappropriate handling, poor product knowledge, and inappropriate storage. The findings also agreed with the studies of Domingo, (2015); Ajayi *et al.*, (2017); and Holt, (2014), revealed that sources of waste revolve around the following procurement factors: delivery methods, delivery schedules, purchase of inadequate materials, poor quality of materials, no take-back schemes, poor advice from suppliers, and poor supply chain management.

Lack of awareness, incentives, support from senior management, and lack of training are all cultural factors that led to waste in the workplace. This study findings in line with the studies of Ekanayake and Ofori, (2004); Innes, (2004); and Keys, *et al.* (2000); that found that these factors contributed to waste generation. The Pearson Chi-square statistic result (f) = 1.833a p-value = 0.400 ($p < 0.05$) obtained. This implies that the factors are interdependent that give sufficient evidence to deduce that the amount of trash produced in private and public building projects differs significantly statistically. The research categorized waste management practitioners' difficulties on construction waste sites into four groups: technical, sociocultural, legal/policy, and environmental. The two biggest overall challenges faced by waste management practitioners on construction waste sites were identified as poor on-site worker skills in construction practices and the inability to manage construction waste effectively due to space constraints (MIS = 4.54 and 4.54, respectively).An eight-pronged plan has been devised as a result of the research to encourage construction waste management at different phases of private and public projects. The goal of the approach is to overcome obstacles to waste management.

4.8 Summary of Findings

Based on the findings from the results of data analyses undertaken in this study, the following are the major findings:

i. The study sampled 60 privately owned construction projects and 60 publicly owned construction projects.

ii. The study classified factors contributing to waste generation on construction sites into four categories: procurement, handing, operation, and cultural factors. Damages due to transportation (MIS = 3.70) are identified as the most important overall factor contributing to waste generation on construction sites. This was followed by rework, variation, and negligence (MIS = 3.62).

iii. The result of the Pearson Chi-square statistic (f) = 1.833a p-value = 0.400 ($p < 0.05$). This indicates that the variables are dependent, thus providing enough evidence to infer that there is a significant statistical difference between the level of waste generated in private and public construction projects.

iv. The study classified waste management practitioners' challenges on construction waste sites into four categories: environmental, technical, socio-cultural, and legal/policy. Poor skills in construction practises of on-site operatives and construction waste management cannot be effectively carried out due to limited space (MIS = 4.54 and 4.54), respectively, were identified as the most significant overall related challenges faced by Waste Management Practitioners on Construction Waste Sites.

v. The study developed an eight-pronged strategy for promoting construction waste management at various stages of private and public projects has been developed. The strategy focuses on eliminating challenges to waste management.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study assessed waste management practices in private and public construction projects in Abuja, Nigeria, with a view to producing environmentally friendly projects and to serve as a guideline for good waste management practice on sites in future. Data was collected from 60 building construction sites located in Abuja. The analysis of the data was carried out with the use of percentage, mean item score, cross tabulation, and chi-square. The results of the analysis carried out led to the conclusions made in this chapter.

The most factors contributing to waste generation on construction sites in Abuja are damages due to transportation, rework, variation and negligence, inappropriate storage, inappropriate handling and Poor product knowledge. There is a significant statistical difference between the level of waste generated in private and public construction projects. There are several challenges that waste management practitioners confront at building waste sites in Abuja, based on the overall ranking of the respondents, the most significant challenges faced by waste management practitioners on construction waste sites are poor skills in the construction practises of on-site operatives and construction waste management cannot be carried out effectively due to limited space.

5.2 Recommendations

In the light of the findings and conclusions of this study, the following recommendations were made:

1. Both private and public developers should pay more attention to the factors contributing to waste generation on construction sites, particularly damages due to transportation, rework, variation, and negligence, as well as inappropriate

storage, inappropriate handling, and poor product knowledge, in order to ensure minimal waste at construction sites.

2. Developers should also give more attention to the following challenges: Construction waste management cannot be effectively carried out due to limited space. Poor skills in construction practices of on-site operatives and lack of sustainable building education at the university level so as to ensure effective waste management
3. In order to promote construction waste management in private and public projects in Nigeria all other relevant stakeholders should develop a mechanism which will include all the strategies identified for eliminating challenges to waste management in both public and private sites.

5.3 Contribution to Knowledge

The findings of this study have made the following significant impact in the research domain of waste management in the construction industry:

1. Identification of factors contributing to waste generation on construction sites and compare the level of waste generated and construction waste management performance in private and public construction project in Abuja.

2. The findings and recommendations of this research will open a window, thereby contributing to the academic knowledge and for future research regarding the factors contributing to waste generation on construction sites and challenges of waste management practitioners on construction waste sites.

5.4 Areas for Further Studies

In view of the limitations of this study, the following areas can be researched in the nearest future: a holistic assessment of demolition waste management in the Nigerian construction industry.

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DEPARTMENT OF QUANTITY SURVEYING

SCHOOL OF ENVIRONMENTAL TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

RESEARCH QUESTIONNAIRE

Dear Sir/Ma,

I am a M. Tech student of the above named institution, carrying out a research on the topic: CONSTRUCTION WASTE MANAGEMENT PRACTICES IN PRIVATE AND PUBLIC PROJECTS IN ABUJA, NIGERIA

The researcher seek your co-operation to answers this questionnaire to the best of your knowledge. All the responses would be treated in strict confidence and would be utilized only for the purpose of this study.

Thanks for your cooperation.

Yours faithfully,

USMAN JIBRIL BOKANI
(MTECH/SET/2019/9975)
Phone No:

SECTION A: General Information of Respondent and Organization

Q1. Please provide information about the respondent as requested by selecting one of the options provided.

A	**Type of project**	1	Public	
		2	Private	

B	**Gender of respondent**	1	Female	
		2	Male	

C	**Position of respondent**	1	Project manager	
		2	Site manager	
		3	Supervisor	
		4	Site workers	
		5	Other (specify)	

D	**Education attainments**	1	OND/NCE	
		2	HND/B.Sc	
		3	Mtech/M.Sc	
		4	Ph.D	

E	**Work experience of respondent**	1	Less than 5 yrs	
		2	5 yrs – 15 yrs	
		3	16 yrs – 25 yrs	
		4	More than 25 yrs	

SECTION B: Factors Contributing To Waste Generation On Construction Sites

Q2. Please tick (√) appropriately in the space provided using a Likert scale (1-5) the following factors contributing to waste generation on construction sites.

S/N	Factors contributing	Very effective 5	Effective 4	Averagely effective 3	Rarely effective 2	Not effective 1
	PROCUREMENT					
1	Delivery methods					
2	Delivery schedules					
3	Purchase of inadequate materials					
4	Poor quality of materials					
5	No take back schemes					

6	Poor advice from suppliers					
7	Poor supply chain management					
	HANDLING					
8	Damages due to transportation,					
9	Inappropriate handling					
10	Poor product knowledge					
11	Inappropriate storage					
	OPERATION					
12	Rework, variation and negligence					
13	unskilled labour					
14	Time restraint					
15	Poor communication					
16	Poor coordination between trades					
17	Inclement weather					
	CULTURE					
18	Lack of awareness,					
19	Lack of incentives,					
20	Lack of support from senior management and					
21	Lack of training					

SECTION C

Q3. Kindly rate the volume of waste generated at your construction (a) Large (b) Moderate (c) Small

Q4. Kindly the indicate the volume of waste generated per day per project with the following options

(a) < 1 tonne (b) 1-5 tonne (c) > 5 tonnes

SN	Type of waste	Private			Public		
		< 1 tonnes	1-5 tonnes	> 5 tonnes	< 1 tonnes	1-5 tonnes	> 5 tonnes
1	timber,						
2	concrete,						
3	tiles,						

4	screeds,						
5	reinforcement bar,						
6	plywood,						
7	Plastics						
8	packaging materials						

SECTION D: Challenges of waste management practitioners on construction waste sites

Q4. Please tick (√) appropriately in the space provided using a Likert scale (1-5) on the following challenges of waste management practitioners on construction waste on sites

S/N	Challenges	Very significant 5	significant 4	Averagely significant 3	insignificant 2	Very in significant 1
	Environmental					
1	Lack of sustainable building education at university level					
2	Inadequate training of construction workers on waste handling issues					
3	Lack of awareness on clients about sustainable housing					
4	Insufficient environmental awareness by the industry, political decision makers, and clients					
5	Absence of healthcare and waste handling training for workers					
6	Attention by government and private sector on housing deficit than on environmental issues					

	Technical					
7	Insufficient knowledge on how to implement eco-technologies					
8	Construction waste management cannot be effectively carried out due to limited space					
9	Poor skills in construction practices of on-site operatives					
	Socio-Cultural					
10	Low demand by clients for sustainable buildings					
11	Traditional construction culture and behaviour					
12	Difficulties in changing work practices of workforce					
13	Insufficient gender diversity recognition by the sector					
14	A belief that waste management efforts will never be sufficient to completely eliminate waste					
	Legal/policy					
15	Insufficient regulation support					
16	Existing regulations are difficult to operate in practice					
17	Lack of enforcement of construction and waste management policies and plans					
18	Deficiency of environmental					

	regulations					
19	Lack of available information regarding the requirements of environmental norms					

SECTION E: Strategies for promoting construction waste management in private and public projects in Abuja .

Q5. Please tick (√) appropriately in the space provided using a Likert scale (1-5) the following Strategies for Promoting Construction Waste Management and Management Stages Of Projects

S/N	Strategies	Very significant 5	significant 4	Averagely significant 3	insignificant 2	Very in significant 1
1	Site Waste Management Plans					
2	Proper Design					
3	Deconstruction					
4	Prefabrication and Modular Construction					
5	On-Site and Off-Site Waste Sorting					
6	Reduce, Reuse and Recycling					
7	Circular Construction					
8	Zero Waste Approach					