KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY KUMASI, GHANA

DEVELOPING A CRITERIA FOR MEASURING THE ENVIRONMENTAL PERFORMANCE OF CONSTRUCTION ACTIVITIES IN GHANA

A Thesis submitted to the Department of Construction and Management Technology, Kwame Nkrumah University of Science and Technology In partial fulfillment of the requirements for the degree of

Master of Science

By

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DECLARATION

I, Bright Yamoah, declare that this Dissertation, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree in this University or elsewhere.

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ABSTRACT

Construction is the mainstay of every economy and contributes immensely to the gross domestic product. Its contribution toward the development of any nation cannot be under estimated. Despite the massive benefits drive from this construction activities it impacts negatively on the environment throughout the life cycle of development. These impacts occur from early work on-site through the construction period, operational period and to the final demolition when a building comes to an end of its life. This sector has purported to be considered as one of the main sources of environmental pollution and waste in the world. It has massive direct and indirect effects on the environment. The Economy of Ghana is experiencing widespread construction projects which increases the pressure on the environment and generate various waste. Environmental protection is an important issue in developed and developing countries which must be taken into accounts. Construction is not an environmentally friendly process by nature as indicated by some researchers. The study aim to develop a criteria for measuring the environmental performance of construction activities in Ghana. Giving more drive to the study, emphasis was laid on the following objectives which formed the core component of this study; assessing the major impact of construction activities on the environment during the construction process, determining the perceptions of construction experts (structural engineers, architects and quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana, determining the most significant factors that influence material waste production during construction as well as proposing and validating a workable criteria for measuring the environmental performance of construction activities in Ghana. The main tools for the collection of data included questionnaires, interviews and site observations. The target population for the data collection included structural engineer's project managers architectural and quantity surveying firms. Statistical package for social scientists (SPSS version 20.0) was employed to analyze data obtained. Relative Importance Index was also applied. The resultant outcome from the analysis indicated that consumption of large amounts of energy during the processing of materials, construction processes and in the use of constructed structures, dust and gas emission released during the production and transportation of materials, disruption of people living in the vicinity of construction projects through traffic diversion, noise pollution and others, Production of substantial volumes of waste and Waste water discharge are most important factors that impact on the environment during the construction process. Similarly Raw materials consumption was determined by all respondents under the resource consumption group of environmental impacts as the principal environmental impact of construction activities in Ghana. The study revealed that poor delivery method, poor product knowledge, inclement weather and lack of training account for material waste generation during construction. It is therefore recommended with a cue from this study that, the national building regulations should be reviewed to take into consideration of environmental regulations. Similarly, all forms of construction activities should be subjected to an environmental impact assessment to determine the potential impacts and also come up with some measures before they are executed.

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DEDICATION

I wish to dedicate this work to the Lord Almighty for His strength and wisdom and also to my lovely wife Vivian Konadu Yamoah, my son Oheneba Kofi Konadu Yamoah and the entire Yamoah's family.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Construction activities are deemed to be one of the main sources of pollution in the environment and waste in the world at large. It has direct and indirect influences on the environment. The economy of Ghana is witnessing widespread construction projects which increase the pressure on the environment and generate various waste. Environmental protection is an important issue in developed and developing countries (Tse, 2001). Construction is not an environmentally friendly process by nature (Li et al., 2010). Levin (1997) indicated that building construction and operations have a massive direct and indirect effect on the environment. Ijiga et al. (2013) emphasized that identifying the impacts of construction project on the environment is a task that needs to be accomplished to realize an effective environmental protection .

Shen et al. (2005) claimed that construction is a main source of environmental pollution, compared with other industries. Li et al. (2010) agreed with Shen (2005) and maintained that any typical construction process involves using various construction equipment's and natural resources and generates many pollutants. Several writers (Morledge and Jackson, 2001; Ball, 2002; Chen et al., 2004; Lam et al., 2011; Zolfagharian, 2012) summarized these pollutants as noise, air pollution, solid and liquid waste, water pollution, harmful gases, and dust. Furthermore, construction projects have become one of the driving forces for the national economy, whose energy consumption, environmental emissions, and social impacts are significant (Chang et al., 2011).

It has been reported that very few contractors and private developers spend efforts in considering the environment and developing the concept of recycling building materials

(Lam, 1997), because most of them ranked completion time as their top priority and pay little attention to the environment (Poon et al., 2001). Zolfagharian (2012) concluded that the level of knowledge and awareness of project participants, especially project managers, with regards to environmental impacts of construction processes needs to be enhanced. Gangolells et al. (2011) agreed with Zolfagharian (2012) at this point and claimed that enhancing the identification of the major environmental impacts of construction processes will help to improve the effectiveness of environmental management systems. Unfortunately developing countries are suffering from the limited scientific data about the impacts of building materials and technologies on the environment and it is difficult to make informed choices aiming at reducing such impacts (Pittet and Kotak, 2009). This study aims to assess the environmental impacts due to construction projects activities in Ghana and to propose some ideas in curbing down these adverse impacts.

1.1.1 Impact of construction on the environment

Any development project plan to improve the quality of life has some built-in positive and negative impacts. The development project should be planned in such a manner that it has maximum positive impacts and minimum negative impacts on the environment (Kaur and Arora, 2012). Prediction of the environmental impacts of construction in the early stages of projects, may lead to improvements in the environmental performance of construction projects and sites (Gangolells et al., 2011). It is expected that construction damages the fragile environment because of adverse impacts of construction. This impact includes resource depletion, biological diversity losses due to raw material extraction, landfill problems due to waste generation, lower worker productivity, adverse human health due to poor indoor air quality, global warming, acid rain, and smog due to emissions generated by building product manufacture and transport that consumes energy (Lippiatt, 1999). Environmental impacts are categorized into three safeguard subjects: ecosystems impact, natural resources impact and public impacts (Li et al., 2010; Chang et al., 2011; and Zolfagharian et al., 2012).

1.1.2 Impact of construction activities on Natural resources

Various natural resources are used during any typical construction process, this resource include energy, land, materials, and water (Shen et al., 2005). In addition, construction equipment operations consume a lot of natural resources, such as electricity and/or diesel fuel. Construction sector is responsible for consuming a high volume of natural resources and generation a high amount of pollution as a result of energy consumption during extraction and transportation of raw materials (Li et al., 2010; and Morel et al., 2001). Construction sector generate worldwide substantial environmental impacts. It contributes to about half of the total energy consumption of high-income countries and is responsible of a major share of greenhouse gas emissions also in developing nations (Stern et al., 2006; Asif et al., 2007; Cole, 1999; and Emmanuel, 2004). Some of the available statistics indicate that the construction and operation of the built environment accounts for: 12-16 % of fresh water consumption; 25% of wood harvested; 30-40 % of energy consumption; 40% of virgin materials extracted and 20-30% of greenhouse emissions (Macozoma, 2012).

1.1.3 Impact of construction activities on the public

Most construction projects are located in a densely populated area. Thus, people who live at or close to construction sites are prone to harmful effects on their health because of dust, vibration and noise due to certain construction activities such as excavation and pile driving (Li et al., 2010). During the construction phase of a project, construction dust and noise are regarded to be two major factors that affect human health (Tam et al., 2004). Li et al. (2010) and Zolfaghrian et al. (2012) conducted a research about environmental impacts of construction in United States of America; they categorized the environmental impact into three safeguard categories: ecosystems, natural resources, and public impacts.

Li et al. (2010) stated that health damage accounts for 27% of the total impact, which is less than the ecosystem damage (65%), but far beyond the resource depletion (8%), which justifies the necessity of performing health damage assessment. Zolfaghrian et al. (2012) confirmed that transportation resources, noise pollution, and dust generation with construction machinery are the most dangerous environmental impacts on construction sites.

1.2 PROBLEM STATEMENT

In order to minimize the environmental impacts during the construction period, constant observation and assessment should be carried out (Lauwerys et al., 1993) . To attain sustainable construction in Ghana, factor affecting the environmental impacts and the degree of pollution towards the environment should be acknowledged (Gyasi-Mensah and Hu, 2018). The state of affairs of the construction industry in Ghana is not quite different from other developing countries. The focus of the Ghanaian construction industry is largely on economic growth and improving the quality of life of the people whilst environmental protection is completely reduced. Thus, the construction industry is considered as one of the prime sector in the Ghanaian economy showing its contribution to the social and economic gains whilst its negative contribution to the environment is absolutely neglected (Aryee, 2001). Regardless of the social and economic gains, construction activities extend beyond the erection of houses, hospitals, schools, offices and factories to civil engineering works such as roads, bridges and communication infrastructure which support the economy. In meeting these demands, the Ghanaian construction industry exerts massive pressures on global natural resources. In the light of the negative repercussion created on the environment as a result of construction activities, there is need to adopt a good strategies to help curb these menace.

Several waste management techniques and strategies have been adopted over the years, with ability to efficiently manage waste becoming criteria for measuring successful construction operations (Peng *et al*, 1997). Governments across nations have formulated various strategies towards minimizing waste to landfill, thus becoming a major driver of construction waste management in many countries (Yuan, 2013). In a bid to ensure that economic growth associated with increasing construction activities does not result in increasing waste and environmental pollution, waste management across the entire project lifecycle should remain a top priority of every construction project planned to be executed (Yuan, 2013) . In a way will aid construction professionals in tackling impending environmental problems associated with waste generation.

It is against this background that investigating criteria for measuring the environmental performance of construction activities in Ghana and drawing the attention of construction practitioners on the measures to minimize the impacts assume great importance.

1.3 AIM

The study aims to explore criteria for measuring the environmental performance of construction activities in Ghana.

1.4 OBJECTIVES

To help achieve the aim, the following objectives were set;

- To assess the impact of construction activities on the environment during the construction process.
- To determine the perceptions of construction experts (structural engineers, architects and quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana
- To determine the most significant factors that influence material waste production during construction

- To make suggestion and recommendation towards the adoption of effective policy and measure that would address the impact of construction activities in Ghana.

1.5 RESEARCH QUESTIONS

In embarking upon such study, certain questions should be answered before any credible conclusions can be drawn. The following questions were posed;

- What are the impacts of construction activities on the environment during the construction process.?
- What are the opinions of construction professionals concerning the influences of construction activities on the environment in Ghana ?
- What are the factors that influence material waste production during construction activities?
- What measures can be put in place to address the impact of construction activities in Ghana?

1.6 RESEARCH APPROACH

The study adopted the concurrent mixed study design (Quantitative and Qualitative). Quantitative research investigates facts and tries to establish relationships between these facts. While qualitative research is a subjective assessment of a situation or problem, and takes the form of an opinion, view, perception or attitude towards objects. A combination of quantitative and qualitative approach is advocated because it takes advantage of the strengths in the two approaches while limiting the weaknesses. Quantitative study of human phenomena can only give frequencies of occurrences of certain observable manifestations of the phenomena without explaining why they occur. Therefore, it is important to also adopt a qualitative research paradigm to compensate for the limitations of using quantitative approach for a study.

1.7 RESEARCH METHODOLOGY

The scope of research is mainly focus on the literature review, questionnaire survey, and interview. The environmental impacts that investigated in this research included destruction of the natural environment and waste normally generated in the course of executing construction activities. The questionnaire survey was designed based on factors identified from literature review that contributed to causes of pollution and impact of waste generated on the environment. The questionnaire survey was distributed to the developers, consultants, and contractors and other construction professionals in the Ghanaian construction industry. Interview was accomplished by the interviewees regarding to issues of environmental impacts.

Advocates mentioned refer exactly to the site managerial staffs concerned such as project managers, quantity surveyors and architects. The study focused on construction sites in Accra and Kumasi where most of the major construction industry are concentrated.

1.8 SIGNIFICANCE OF THE STUDY

The study seeks to have positive implications on the Ghanaian building construction industry. In this regard;

The results will enable building organizations to improve construction quality and efficiency through the implementation of the measures suggested to reduce the negative repercussions created during construction activities. Minimizing construction waste on the environment and creating public awareness would improve project performance and enhance value for money and have a positive impact on the national economy.

1.9 ORGANIZATION OF THESIS

Chapter (1) consists of a research background of construction industries in Ghana, follow by the discussion of the problems statement, aim and objectives, scope and limitation of this study. And lastly, the chapter outline of this study.

Chapter (2) contains literature review which is through, comprehensive, relevant, and consistent with the research topic. In this chapter, construction activities, impacts of construction industry to the environment and assessment of environmental impacts due to construction activities will be discussed. Besides that, critical points of view are concluded to the study.

In Chapter (3), theoretical aspect of research methodology will be carried out. Various approaches have been used to conduct this research to data collection. This chapter also includes the research design; which demonstrate how the questionnaire survey and interview are designed and how the data is collected.

Chapter (4) will present the result of data collected and analysis data based on respondents' feedback. The consistency of the survey results will be evaluated and discussed by application of suitable literature reviews. A summary on the interviewee's opinions will be carried out and critical comment will be made on the summary.

In the final Chapter, the conclusion of the analysis will be carried out. And lastly, some recommendations and suggestions to solve improve the current environmental impacts due to construction activities will be included.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTODUCTION

The construction industry is one of the mainstay for the development of any nations, providing the requisite infrastructure and physical structures for activities such as commerce, services and utilities. The industry generates employment opportunities and injects money into a nation's economy by creating foreign and local investment opportunities (Agung, 2009). However, despite these contributions, the construction industry has also been linked to global warming, environmental pollution and degradation (Jones & Greenwood, 2009). Construction waste generation and unsustainable use of depleting natural resources as building materials, are also linked to the adverse environmental impacts of the construction industry. Globally, it is estimated that approximately 10 to 30 per cent of wastes disposed off in landfills originates from construction and demolition activities (Fishbein, 1998). In Malaysia, construction waste is one the single largest waste stream and yet despite a number of government policy initiatives to address this issue,, sustainable resource and waste management on site remains a low priority for the majority of the contractors (Begum, 2009). It is therefore prudent to address environmental issues at the outset; otherwise our created wealth of the constructed asset will be significantly undermined. This chapter reviews literature on the Ghanaian construction industry, the global construction industry, impact of construction activities on the environment, materials waste minimization strategies.

2.2 CONSTRUCTION INDUSTRIES IN DEVELOPING COUNTRIES

Considering the investments levels of the construction industry and the development needs of most developing countries, the time is overdue for these matters to be given prominence. This is also because, despite the relatively high investment in infrastructure in developing countries, the World Development report (1994) highlights the less corresponding impact these have had on the people in these countries. Hence, the report indicated that the infrastructure's future challenges should be dealt with by tackling inefficiency and waste – both in investment and delivering services. The report indicated that the poor performance of those managing the delivery and maintenance of these infrastructures provides strong reasons for doing things differently. Indeed, Agenda 21 for sustainable construction in development countries puts construction at the centre of how the future is to be shaped, and the sustainability of this future (Du Plessis, 2002 pi). In particular, developing countries were well advised to avoid the development mistakes of the developed world and to take steps to intervene on behalf of sustainability today than to wait and change things after they have occurred (Du Plessis, 2002 p1). Even though the research does not cover sustainable construction, this advice is seen as another reason why developing countries should make efforts to deliberately address the many problems that confront their construction industry, particularly, in the area of project performance.

2.3 THE GHANAIAN CONSTRUCTION INDUSTRY

The Ghanaian construction industry is multifaceted in nature, representing a range of stakeholders (Ahmed *et al*, 2014). The Ministry of Water Resources, Works and Housing, accountable for the housing infrastructure and construction throughout the country, categorizes building contractors into four groupings: projects worth up to $75,000 (D4K4); projects ranging from $75,000-250,000 (D3K4); projects worth $250,000-500,000 (D2K2); and projects over $500,000 (D1K1) (Ahmed *et al*, 2014). The majority of the companies in Ghana fall under D4K4 and D3K4 classification (Oxford Business Group 2014). The Chartered Institute of Building in Ghana estimates that there are over 1,600 building contractors working in Ghana since October 2012 (Oxford Business Group 2014). Although the building construction industry assists the country's economy and thus offers a means for social development, the industry is characterized by unprofessional practices (Ahmed *et al*, 2014). The industry suffers from a lack of planning, including unsuitable water and energy use, building material consumption, failure to meet consumer/tenant needs, and disjointed stakeholders cooperation in the industry. These deficits form part of an industry mired in corruption without transparent processes for acquiring the services of consultants and contractors (Ahmed *et al*, 2014). The unsustainable building construction processes coupled with the constant degradation of the environment continue to take their toll on Ghana's development (Ahmed *et al*, 2014). The problem-ridden industry must also deal with a national housing problem in need of 70,000 units annually and an accumulated delivery deficit of 250,000 units to meet the housing demands. These numbers are backed up by the U.N. Human Settlement Program who estimate that Ghana will need two million new housing units by 2020 to meet the demand for housing. The sustainability challenge facing the construction industry is to meet the demand for housing and other buildings in a strategic and sustainable manner. Ordinarily stakeholders within the industry have the power and capacity to influence the positive changes necessary to improve the state of the industry (Ofori, 2012). Currently, the approach the Ghanaian building construction industry is employing to tackle existing challenges is not cohesive and is adopted differently by the government and private organizations, rendering most efforts ineffective. This current approach is unstructured and contributes to a further challenge of meeting the demand for housing units. These "affordable" or low cost houses are traditionally built with local materials such as brick and tile, land concrete, adobe bricks, compressed earth bricks, pozzolana cement, bamboo, and secondary timber species to reduce costs. This approach, however, has yet to align the notion of "affordable" with the real cost of the market and lacks common consensus among the stakeholders in the industry. This has often resulted in many building construction failures and is indicative of a lack of understanding and dialogue among stakeholders in the industry (Ahmed *et al*, 2014) also clarifies that most construction projects in Ghana have a long development period due to their large and complex nature and thus are slow to respond to planned and unplanned changes. Therefore, is quite expedient to reduce the sustainability problems encountering in the building construction industry by incorporating sustainability into its normal practices.

2.4 CONSTRUCTION WASTE: DEFINITION AND MEASUREMENT

Numerous classification models have been applied to classify the types of waste. Wastes can be classified by their state (solid, liquid or gaseous); by their characteristics (inert, combustible, bio-degradable, hazardous or nuclear); or by their origin (processing, household, emission treatment, Construction & Demolition or energy conversion). Demolition and Construction (D&C) waste can then be defined and studied separately.

Construction waste has been defined in various ways. The Building Research Establishment (1978) defined waste as 'the difference between materials ordered and those placed for fixing on building projects'. In 1981 another definition emerged from BRE stating that waste is 'any material apart from earth materials, which needed to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project'. In the 1990's the Environmental Act (1990) defined waste as: 'scrap material or an effluent or other surplus substance arising from the application of any process.

Koskela (1992) and Alarcon (1993) studied other types of waste in construction. Time and process waste is generated from activities that take time, resources or space without adding value. Formoso et al. (1999) added that defined time and process related waste as: 'any losses produced by activities that generate direct or indirect costs but do not add value to the product from the point of view of the client'. Non adding value activities and how to reduce the waste they generate are the basis of the lean construction philosophy. Although inefficiency related waste has greater economic loss than material waste (Formoso et al., 1999), it is widely recognized that the latter is more important from an environmental perspective (Formoso et al., 1999).

Similarly to the definition of waste, waste measurement has been also viewed and implemented in different ways. Treloar et al. (2003) suggest the measurement of waste in terms of embodied energy of materials. Bossink and Brouwers (1996) reported 3 case studies where waste of each type of material was measured in different ways:

i) as a percentage of the total amount of construction waste;

ii) as a percentage of purchased materials; and

iii) as a percentage of the total waste's cost.

These methods are all illustrative of the level of waste generated and they can be used simultaneously. However, in order to calculate these percentages, the identification of waste streams and volume/weight of waste generated for each one is necessary.

In addition to the fact that recording and measuring waste is a prerequisite to its management (Wrap, 2007b), knowing how much waste is generated can be used as a benchmarking tool against other projects; other companies; or against good practice. The next step is then to explore the gap between what is achieved and good practice. Reducing the gap can be attained by looking at the sources of waste and analyzing the causes behind its generation.

2.4.1 TYPES OF MATERIALS ARISING FROM DIFFERENT STAGE OF CONSTRUCTION.

According to (Alfreton, 2015), different types of materials arise from each stage in construction. The table 2.1 clearly spells out the construction stages with the type of waste produced at each stage.

Table 2.1 the construction stages with the type of waste produced at each stage.

CONSTRUCTION STAGE	WASTE TYPE
Demolition	Concrete, inert, soils, bricks, hazardous waste, wood, metal, plastic, glass, plaster, asbestos, electrical items, asphalt
Earthworks/groundworks	Inert, mixed, concrete, soils, green waste
Substructure	Concrete, metals, packaging, aggregate.
Structural and drainage	Bricks, blocks, glass, timber
Internal substructure	Blocks, plasterboard, special (hazardous), paint and plaster packaging timber, plastic products, paper and cardboard.
External/drainage	Plastic, soils inert, timber, packaging

Source: (Alfreton, 2015)

2.5 ASSESSMENT OF ENVIRONMENTAL IMPACTS FROM CONSTRUCTION ACTIVITIES

Activities that may cause environmental impacts during construction include site preparation (e.g., clearing and grading); facility construction (e.g., geothermal power plant, pipelines, transmission lines); and vehicular and pedestrian traffic. Shen and Tam (2002) classified construction environmental impacts as the extraction of environmental resources such as fossil fuels and minerals; extending consumption of generic resources, namely, land, water, air, and energy; the production of waste that require the consumption of land for disposal; and pollution of the living environment with noise, odours, dust, vibrations, chemical and particulate emissions, and solid and sanitary waste. The generic resources which are considered as influential in human life but when treated badly may cause inconvenience in human existence.

2.6 CONSTRUCTION SITES INCONVENIENCES

The resulting inconveniences of the activities of a construction project are numerous. Regarding this theme, an attempt was made to order each impact by the importance given to each one in scientific publications, being the following the most frequently mentioned

(Teixeira & Couto 2000). These inconveniences are below listed:

- Production of residue
- Mud on streets
- Production of dust
- Soil and water contamination and damaging of the public drainage system
- Damaging of trees
- Visual impact
- Noise
- Increase in traffic volume and occupation of public roads
- Damaging of public space

2.6.1 Waste production

Like any other economic activity, construction uses natural resources and produces waste. The amount of waste generated by construction and demolition activity is quite a lot. Surveys conducted in several countries found that it is as high as 20% to 30% of the total waste entering

landfills throughout the world. Besides, the weight of generated demolition waste is more than twice the weight of the generated construction waste. Other studies compared new construction to refurbishment, and concluded that the later accounts with more than 80% of the total amount of waste produced by construction activity as a whole. The building activity at historical city centres tends to be an important waste generator because both refurbishment projects and new projects often include demolition (Teixeira & Couto 2000).

2.6.2 Mud in streets

Earth movements taking place in raining days normally lead to the deposition of mud if tyres of lorries are not cleaned when leaving the construction area. Result are unpleasant aspect of streets, increased risk of car accidents and bigger maintenance costs for public space and private properties (Teixeira & Couto 2000)

2.6.3 Dust production

Earth movements and demolitions often encompass the production of blowing clouds of dust with severe effects in the increasing number of those suffering from breathing diseases and unpleasant effects in deposition surfaces (Teixeira & Couto, 2000).

2.6.4 Contamination of land and water and damaging of the public drainage system

Construction makes use of a set of pollutant fluids that may spoil the land and adjacent pavements. Direct evacuation to the sewing system is inconvenient and should in some cases be forbidden because they may damage pipes and treatment plants. Paints, solvents, oils and washing water from construction sites are some examples of dangerous products. Pavements in centres are sometimes of considerable value and the risk of degradation should therefore be avoided. Sewers are often very old and quite sensitive to possible aggressions. Repairing costs of such infrastructures tend to be high for several reasons and cause severe inconveniences both in living and visiting population (Teixeira & Couto 2000)

2.6.5 Damaging of trees

The activity of construction sites may damage trees within the site and its vicinity. Trees being important natural elements in the urban landscape, as they beautify it, provide shades, shelter forbirds, purify the air and retain moisture, among other things, their preservation is a must. In spite of their bulk, trees are delicate living beings; therefore, construction sites must be carefully prepared. Many times, the damage caused only becomes apparent a full year, or years after completion of the construction project. Many actions may damage and even kill trees (City of Huntsville Urban Forestry Section 2000)

(Gary 1999): soil compacting, increase in soil height, opening ditches and trenches, removal of topsoil, loss or damage to the roots, damage to trunks and leaves, and more

2.7 SOURCES OF MATERIAL WASTE IN CONSTRUCTION

Many factors contribute to the generation of material waste. These factors have been grouped by Ekanayake & Ofori (2000) under four categories: (1) design; (2) procurement; (3) handling of materials; and (4) 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; Rounce, 1998). It is, thus, agreed that the process of waste minimization 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. The UAE construction industry is witnessing an unprecedented boom. A lot of mega projects are underway and contractors are enjoying high profit margins in a tax free economy (El-Sayegh, 2008). Therefore it is important to focus on contractors' attitudes towards waste and on waste generated as a result of construction site activities. In addition to excessive cut off resulting from improper design, the three aspects to be investigated in detail are Procurement, Operation and Handling. It is worth noting that waste generation is not only a technical issue but a behaviouristic one as well. Teo et al. (2000) stated that "the labour intensive nature of construction activity suggests that behavioural impediments are likely to influence waste levels significantly". This statement was supported by Lingard et al. (2000) who pointed out that effective waste minimization depends on the extent to which participants to the construction process change their behaviour in relation to waste issues. Therefore, sources of waste revolve around four factors namely: procurement, handling, operation and culture.

According to Lingard et al. (2000), a review of the main origins of material waste belonging to each category is summarized below.

Table 2.2. The main origins of material waste

Origin of construction waste	Factor attributed to construction waste
1. Procurement waste	Delivery methods • Delivery schedules • Purchase of inadequate materials • Poor quality of materials • No take back schemes • Poor advice from suppliers • Poor supply chain management
2. Material Handling waste	• Damages due to transportation • Inappropriate handling • Poor product knowledge • Inappropriate storage
3. Operation waste	• Rework, variation and negligence • Unskilled labour • Time restraint • Poor communication • Poor coordination between trades • Inclement weather
4. Culture	• Lack of awareness • Lack of incentives • Lack of support from senior management • Lack of training

Source: (Lingard et al, 2000)

2.8 CONSTRUCTION WASTE

There are differing views held by researchers as to what constitutes Construction waste. Cheung, (1993) stated that Construction Waste can be defined as the byproduct generated and removed from construction, renovation and demolition workplaces or sites of building and civil engineering structures. The Building Research Establishment (1982, cited in Skoyles and Skoyles 1987) defines construction waste as the difference between the purchased materials and the used in a project. According to Hong Kong Polytechnic (1993) construction waste is the "by-product generated and removed from construction, renovation and demolition work places, or sites of building and civil engineering structures". Similarly, construction waste has been defined as "building and site improvement materials and other solid waste resulting from construction, re-modelling, renovation, or repair operations"(Harvard Green Campus Initiative, 2004). Although, resource optimization is one of the main objectives of any organization, less attention is paid on construction waste minimization even though it has a great contribution to the aforesaid objective. This is due to the perception regarding waste which "has no value and which the junkman can take away (Leenders et al. 1990).

Construction and Demolition waste is a complex waste stream, consist of a wide variety of materials which are in the form of building debris, rubble, earth, concrete, steel, timber, and mixed site clearance materials, arising from various construction activities including land excavation or formation, civil and building construction, site clearance, demolition activities, roadwork, and building renovation. It also includes incidences of wastages in labour and energy used in construction works. Conversely, material waste has been acknowledged as a major problem in the construction industry that has significant implications both for the efficiency of the industry and for the environmental impact of construction projects (Formoso et al, 2002). Most construction wastes which were previously considered as inert have been establish to generate harmful leachates which have harmful effects on the environment (Apotheker, 1992, cited in Lingard et al, 2000). For this reason, it is quite prudent for the construction industry to accept ecologically sound planning and construction practices for the purpose of creating a healthy and sustainable built environment (Poon et al, 2004)

2.9 FACTORS RESPONSIBLE FOR WASTE IN CONSTRUCTION INDUSTRY

Waste generated at the construction site may come as a results of, renovation, and repairing work. There are several ways in which the generation of construction waste occurs. During the design and construction stage waste may occurs leading to the destruction of the natural environment and extinction of wild life conservation..

Basically, there are numerous factors accountable waste generation in the construction sites. These are stated below:

2.9.1 Natural waste

Natural waste is the excess that will cost more than what is saved if tried to prevent. There is a certain limit up to which, waste of materials can be prevented. Beyond that limit, any action taken to prevent waste will not be viable, as the cost of saving will surpass the value of materials saved. Thus, natural waste is allowed in the tenders. Amount of natural waste is subjective to the cost effectiveness of the approaches used to manage it. The approaches vary from one scenario to another and so do the natural waste. For instance, cost of preventing wastage in a project with a good material controlling policy will be lesser than that of a project, which lacks such a policy. Thus, the acceptable level of natural waste in the former situation will be lesser than the later (Agyekum, 2012).

2.9.2 Direct waste

"Waste that can be minimised and include the removal and replacement of material" is called as direct waste more often, the cost of direct waste does not end up in the cost of material, but followed with the cost of removing and disposing. Thus, by avoiding direct waste straightforward financial benefits can be obtained. Direct waste can be occurred at any stage of the construction process before the delivery of material to the site and after incorporating the materials at the building (Agyekum, 2012). Categories of direct waste can be summarized as in

Table 2.3 Categories of direct waste

CATEGORY	REASON	EXAMPLE
Delivery waste	During the transportation of material to the site, unloading, and placing in to the initial storage	Bricks, glassing
Cutting and conventional waste	Cutting materials in to various sizes and uneconomical shapes	Formwork, tiles
Fixing waste	Dropped, spoiled or discarded material during fixing	Bricks, roof tiles
Application and residue waste	Hardening of the excess materials in containers and cans	Paint, mortar, plaster
Waste caused by other trades	Damages occurs by succeeding trades	Painted surfaces
Criminal waste	Theft and vandalism	Tiles, cement bags
Management waste	Lack of supervision or incorrect decisions of the management	Throwing away excess material
Waste due to wrong use	Wrong selection of material	Rejection of inferior quality marbles, tiles

Source: (Skoyles and Skoyles, 1987)

2.9.3 Indirect waste

In this type of waste, the material does not get waste physically, but the payments for the material are wasted partly or wholly (Agyekum, 2012)

The indirect waste consists of the following categories as shown in Table 2.4

Table 2.4: Categories of indirect waste

CATEGORY	REASON	EXAMPLE
Substitution waste	Substitution of materials in work, which will incur losses to either contractor or client	Use of facing bricks for common bricks
Production waste	Contractor does not receive any payments for the work he has carried out	Use of excess plastering to rectify the uneven surfaces of brick walls
Negligence waste	Site errors because of the condemned work or use of additional material	Over excavation of foundation, resulting in the use of additional concrete
Operational waste	Unavailability of proper quantities in the contract document / the material that are left in the site	Formwork

Source : (Skoyles and Skoyles, 1987)

In addition to the above classifications, Ekanayake and Ofori (2000) have grouped the sources of waste under four major categories as Operational waste (errors by trade persons or labourers, accidents due to negligence, damage to work done created by successive trades, use of inappropriate materials, required quantity unclear due to unsuitable planning, equipment malfunctioning, severe weather), Design waste (lack of attention paid to dimensional co-ordination, changes made to the design while construction is in progress, designer's inexperience in method and sequence of construction, lack of attendance paid to standard sizes available on the market, designer's unfamiliarity with alternative products, complexity, errors and incomplete contract documents, selection of low quality products), Material handling (Damages during transportation, inappropriate storage, materials supplied in loose form, use of whatever material which are closed to working place, unfriendly attitude of project team and labourers, theft) and Procurement waste (Ordering errors, lack of possibilities to order small quantities, purchased products that do not comply with specification).

2.10 ENVIRONMENTAL PERFORMANCE

Construction industry has been regarded as a major contributor to environmental impacts. Construction projects affect the environment in numerous ways across their life cycle (Shen *et al.,* 2000). For example, 14 million tonnages of waste have been put into landfill in Australia each year, 44 % of the waste is attributed to the construction/demolition industry (Songer and Molenaar, 1997). 62-86% local productions of non-metallic minerals, such as glass, cement, clay, and lime and so on in developing regions are for the construction industry (UNIDO, 1985). The Technical Committee (TC) was formed in January 1993 by the International Organization for Standardization (ISO) to develop a series of standards, which are known as ISO14000 series. It contains 21 standards and guidance documents on environmental management and provides a standard of suitable environmental management practice. Environmental issues are a global concern. The UN and some economics unions such as the European Community and ASEAN have introduced environmental protection model laws or directives to member countries (Wong and Chan, 2000). Environmental Impact Assessment (EIA) Ordinance is now a extensively accepted statutory framework for prediction and assessment of potentially adverse environmental impacts from development projects (Environmental Protection Department, 2000). The enforcement of EIA Ordinance offers a good measure for environmental

2.11 RESOURCE DEPLETION, WASTE AND RECYCLING

The construction industry is a conspicuous user of resources. Materials are derived from numerous sources and suppliers, and minimization of waste presents particular problem. Although many of the materials in use are common to most sites, the fragmented nature of development constrains the practical extent of recycling. Furthermore, despite the long life of its products, their eventual demolition or redevelopment can produce significant waste for land disposal unless re-used (Willmott, 2010).

The mass of resources used in the UK construction industry is dominated by stone and primary aggregates: sand and gravel extraction of these primary resources implies major environmental impact from loss of habitat and ecosystem, damage to the landscape, potential subsidence problems and release of methane. Noise and dust and heavy transport through populated areas confer local nuisance and contribute to restricted award of extraction licenses by local authorities. The same issues arise in the disposal or processing/recycling of waste (Willmott, 2010). .

Construction also has a major impact on the environment in its consumption of energy, both directly and embodied in the materials that it uses. The large bulk of materials used consumes a great deal of energy for transport. Taking into account both direct use and embodied energy, the construction industry consumes about 4.5% of the national total as a consequence of this energy consumption, construction generates over 40 million tonnes of carbon dioxide which contributes to global warming from the greenhouse effect (Lenzen and Treloar, 2002). Acid gases and oxides of nitrogen (NO2) are also produced, contributing to acid rain and photochemical smog production.

The relations between water and energy are progressively becoming more evident. Generating energy uses a lot of water for cooling and a lack of water has already led to power cuts where nuclear power stations have been shut down during droughts. Likewise, treating and pumping drinking water and waste water uses a lot of energy with the UK water industry accounting for around 1% of UK CO2 emissions (McCormack *et al*, 2007). In our homes domestic water heating is responsible for 5% of UK CO2 emissions, and 25% of your household energy bill (McCormack *et al,* 2007). The construction of a house, using a combination of methods, requires about 6 million litres of water (McCormack *et al,* 2007). Throughout the construction cycle, and especially at the end of a structure's life, large quantities of waste are produced. Significant quantities of waste are also generated by the construction process itself. Much of this wastage is avoidable on site, but inattention to design detailing, inappropriate material, dimensions, late variations, over-ordering, etc. also contribute to waste.

Also, resource depletion, waste and recycling are other major impacts of construction. Material extraction of the primary resources cause major environmental impacts through loss of habitat and ecosystem, damage to the landscape, potential subsidence problems, release of methane, transportation of material, Construction and Demolition wastes and its disposal or processing/recycling of waste (Ahmed, 2012).

(Ahmed, 2012) emphasized that, other impact of construction is due to pollution generation and presence of hazardous substances in the natural and built environment. Pollution arising from the built environment includes sewage, waste etc., pollution caused during the manufacture of materials and products, pollution and hazards from the handling and use of materials and actual Construction and site related activities. Considerable pressure can be placed on the local road network and neighboring uses by quarrying operations.

2.12 IMPACT OF CONSTRUCTION WASTE ON THE ENVIRONMENT

The construction industry has an extensive irreversible influence on the environment across a broad spectrum of its activities during the off-site, on site and operational activities, which alter ecological integrity (Uher, 1999).

The construction industry is one of the major exploiters of both renewable and non-renewable natural resources (Spence &Mulligan, 1995; Curwell & Cooper, 1998; Uher, 1999). It depend heavily on the natural environment for the supply of raw materials such as timber, sand and aggregates for the building process. According to World watch institute (2003), building construction consumes 40 percent of the world's raw stones, gravel and sand and 25 percent of the virgin wood per year. It also consumes 40 percent of the energy and 16 percent of water annually. In Europe, the Austrian construction industry has about 50 percent of material turnover induced by the society as a whole per year (Rohracher, 2001) and 44 percent in Sweden (Sterner, 2002).

The extraction of natural resources causes irreversible changes to the natural environment of the countryside and coastal areas, both from an ecological and a scenic point of view (Langford et al., 1999). The subsequent transfer of these areas into geographically dispersed sites not only leads to further consumption of energy, but also increases the amount of particulate matter in the atmosphere. Raw materials extraction and construction activities also contribute to the accumulation of pollutants in the atmosphere. According to Levin (1997), in the USA construction is responsible for 40 percent of atmospheric emissions, 20 percent of water effluents and 13 percent of other releases. Dust and other emission include some toxic substances such as nitrogen and sulphur oxides. They are released during the production and transportation of materials as well as from site activities and have caused serious threat to the natural environment (Spence & Mulligan, 1995; Ofori & Chan, 1998; Rohracher, 2001). Other harmful materials, such as chlorofluorocarbons (CFCs), are used in insulation, air conditioning, refrigeration plants and fire-fighting systems and have seriously depleted the ozone layer (Clough, 1994; Langford et al., 1999). Pollutants have also been released into the biosphere causing serious land and water contamination, frequently due to on-site negligence resulting in toxic spillages which are then washed into underground aquatic systems and reservoirs (Kein et al., 1999). According to Langford et al (1999), about one third of the world's land is being degraded and pollutants are depleting environmental quality, interfering with the environment's capacity to provide a naturally balanced ecosystem. A large volume of waste results from the production, transportation and use of materials (Ofori & Chan, 1998; Kein et al., 1999). It should be noted that construction activities contribute approximately 29 percent of waste in the USA, more than 50 percent in the UK and 20-30 percent in Australia (Teo & Loosemore, 2001). According to Levin (1997), in the USA construction contributes 25 percent of solid waste generation. In the European Union, the construction industry contributes about 40-50 percent of wastes on per year (Sjostrom & Bakens, 1999; Sterner, 2002). Most construction waste is needless (Sterner, 2002). He added that many construction and demolition materials have a high potential for recycle and reuse. Nevertheless, screening, checking and handling construction waste for recycling are time consuming activities and the lack of environmental awareness amongst building professionals may create significant barriers to the usefulness of recycling (Langston & Ding, 1997). The depletion of natural resources by the building industry is a topic of serious discussion as most of the recyclable material from building sites ends up in landfill sites. Sterner (2002) stated that implementing a waste management plan during the planning and design stages can reduce waste onsite by 15 percent, and delivers cost savings of up to 50 percent on waste handling.

Besides producing waste, building activities also irreversibly transforms arable lands into physical assets such as buildings, roads, dams or other civil engineering projects (Spence & Mulligan, 1995; Langford et al., 1999; Uher, 1999). According to Langford et al. (1999), about 7 percent of the world's cropland was lost between 1980 and 1990. Arable land is also lost through quarrying and mining the raw materials used in construction. Construction also contributes to the loss of forests through the timber used in building and in providing energy for manufacturing building materials. Both deforestation and the burning of fossil fuels contribute directly to global warming and air pollution. In addition, building industry considered to be a major consumer of energy and the use of finite fossil fuel resources for this purpose have contributed significantly to carbon dioxide emissions (Clough, 1994; Spence & Mulligan, 1995; Ofori & Chan, 1998; Langford et al., Uher, 1999). In Europe, construction activities have consumed about 40 percent of total energy production (Sjostrom & Bakens, 1999; Rohracher, 2001; Sterner, 2002).

Ultimately, The construction industry plays an indispensable role in providing physical infrastructure to meet the growing societal needs. Notwithstanding, it brings about detrimental effects, such as various forms of environmental pollution and resources depletion (Gang, 2000). The environmental consequences generated from the construction industry relate to many aspects including:

(I) consumption of large amounts of energy during the processing of materials, construction processes and in the use of constructed structures; (ii) dust and gas emission released during the production and transportation of materials and in some construction operations; (iii) disruption of people living in the vicinity of construction projects through traffic diversion, noise pollution and others; (iv) production of substantial volumes of waste; (v) waste water discharge; (vi) use of water resources; (vii) pollution from building materials; (viii) land use and (ix) substantial consumption of both renewable and non-renewable resources (Clemen,1996; Morledge and Jackson,2001); Poon at el, 2001).

2.13 CLASSIFICATION OF ENVIRONMENTAL IMPACTS OF CONSTRUCTION ACTIVITIES

The origin of waste and the hazards can be divided into seven major types: dust, harmful gases, noises, solid and liquid wastes, fallen objects, ground movements and others. Chen et al. (2005) considered construction effects under eight classifications: soil and ground contamination, underground water contamination, construction and demolition waste, noise and vibration, dust, hazardous emissions and odours, wildlife and natural features influence and archaeology impacts. Notwithstanding, Cole (2000) indicated that the environmental influences of the construction practice embrace resource uses, ecological loadings and human health issues. March (1992) perceived the construction industry's environmental impacts under the classifications of ecology, landscape, traffic, water, energy, timber consumption, noise, dust, sewage, and health and safety hazards. Shen and Tam (2002) categorized construction environmental effects as the extraction of environmental resources such as fossil fuels and minerals; extending consumption of generic resources namely: land, water, air, and energy; the production of waste that require the consumption of land for disposal; and pollution of the living environment with noise, odours, dust, vibrations, chemical and particulate emissions, and solid and sanitary waste. Typical negative impacts of the construction activities include waste production, mud, dust, soil and water contamination and damage to public drainage systems, destruction of plants, visual impact, noise, traffic increase and parking space shortage and damage to public space, (Cardoso 2005),.

The aforementioned information clearly justifies that, there is no single approach concerning the environmental impacts associated with the construction process in the literature. Eco-Management and Audit Scheme (EMAS) regulation provides a standardized and comprehensive list of environmental aspects covering almost all the previous mentioned environmental aspects which includes:

- Emissions to air,
- Releases to water,
- Avoidance, recycling, reuse, transportation and disposal of solid and other wastes, particularly hazardous wastes,
- Use and contamination of land,
- Use of natural resources and raw materials (including energy),

- Local issues (noise, vibration, odour, dust, visual appearance, etc.),
- Transport issues,
- Risks of environmental accidents and impacts arising, or likely to arise, as consequences of incidents, accidents and potential emergency situations and
- Effects on biodiversity. However, environmental impacts coming from EMAS regulation had to be customized to the construction processes and for this reason an exhaustive preliminary analysis with a process oriented approach (Zobel & Burman, 2004) was carried out. Environmental impacts provided in EMAS regulation were analyzed for the entire construction process.

2.14 WASTE MINIMIZATION STRATEGY IN THE CONSTRUCTION INDUSTRY

Waste minimization is important in construction industry to protect the environment. Waste minimization is one of the waste management approaches being applied in construction project to reduce the amount of waste generated. On the other hand, there are several authors have discuss and produced their own definition of waste minimization. According to, (Mallak,2014) waste minimization is defined as the reduction of waste during process of products. In addition, it is also called as production material which is environmental friendly. Generally, there are three methods to minimize waste according to USA's Environmental Protection Agency's (EPA) which are reduction, recycling and treatment. Moreover, (Ahmad *et al*, 2014) states that there are three main practices in minimizing waste during construction activities which are; avoiding waste, reuse materials and recycling waste. According to, (Dainty, 2004) waste minimization is often not to be considered in early stage of construction project. Nevertheless, in the hierarchy of waste management, waste minimization is one of the highest levels which are important to achieve the sustainable development. Importantly, it is a ways to reduce waste at source and in order to achieve the waste hierarchy towards 2020 at its objective. The hierarchy of waste in Malaysia is reduce, reuse, recycle, treatment and dispose to minimize the waste generated. Target of Malaysian for recycling is 22% out of waste generated by the year 2020 (Ali *et al*, 2012). Implementation of good practices in management of construction waste contributes to sustainable development and helps to minimize waste in construction site otherwise it will be sent to landfill (Waste & Resources Action Programme, 2007).

2.15 MANAGEMENT OF WASTE IN THE CONSTRUCTION INDUSTRY

Waste management for construction activities has been supported with the purpose of safeguarding the environment and the recognition that wastes from construction and demolition works contribute meaningfully to the polluted environment (Shen et al, 2002, cited in Shen et al, 2004). This increasing awareness of environmental impacts from construction wastes has led to the development of waste management as an important function of construction project management (Shen et al 2004).

There are numerous methods for managing waste in the construction industry. The process of managing construction waste goes far beyond the disposal of the wastes itself. It is an all-encompassing strategy to effectively use construction resources, with the view to decreasing the quantity of waste and also utilizing the generated waste in the most effective manner. The most common approach to management of construction waste is dumping in landfill sites. Contrary, decreasing landfill space has led to increasing costs of landfill disposal to the contractor (BIE, 1993, cited in Lingard et al, 2000). Besides, a relatively huge amount of materials is being wasted because of poor material control on building sites (Poon, et al, 2004). This has stimulated the need for alternatives for waste prevention and the initiatives to reduce, reuse and or recycle waste produced which are referred to as the three R's of construction waste management. A waste hierarchy has been widely adopted as a guide for construction managers, in line with the principles of sustainable construction.

The Waste hierarchy obviously suggests that:

- The most effective environmental solution may often be to **reduce** the generation of waste.
- Where further reduction is not practicable, products and materials can sometimes be **re-used,** either for the same or a different purpose.
- Failing that, value should be recovered from waste, through **recycling**, composting or energy recovery from waste.
- Only if none of these solutions is appropriate should waste be **disposed** of, using the best practicable environmental option. (Source: Department of the Environment, Transport and Regions, 2000)

Considering the views of Coventry and Guthrie, (1998), there are two basic reasons for reducing, reusing and recycling waste: the economic advantages, and the environmental benefits. The environmental advantages include the minimization of the risk of immediate and future environmental pollution and harm to human health while the economic advantages include lower project costs, increased business patronage, lower risk of litigation regarding wastes amongst others. When construction professional are able to comply with the process above, it will go a long way alleviate the threats impose on the environment.

(Envirowise, 2014) clearly stated Waste hierarchy. This spells out the necessary steps to avoid waste if not eliminated.

- Firstly, aim to **reduce** the amount of waste you create.
- If waste is created, identify ways you can **reuse** the materials.
- Finally, if materials cannot be reused then collect them to **recycle**.
- Only dispose of waste as a last resort.

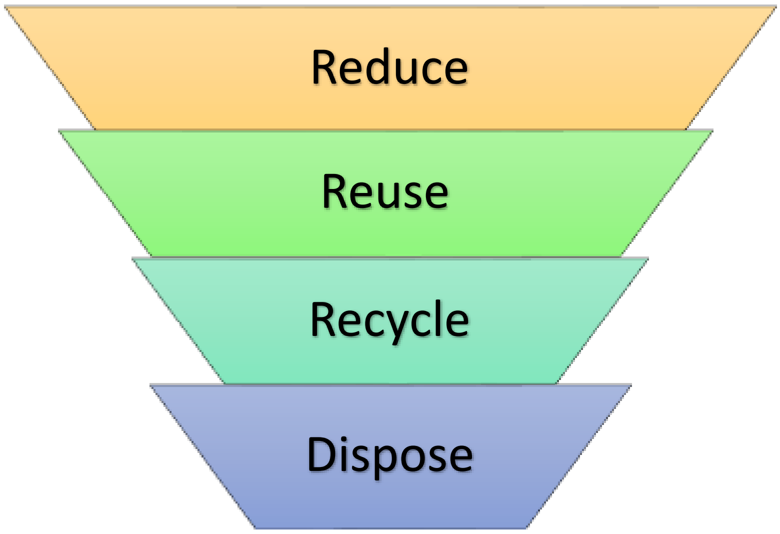

Figure 2.1. Adopted steps to avoid waste if not completely eliminated

Source: (**(Envirowise, 2014)**

Reducing, reusing and recycling your construction waste can bring many benefits.

- **generate income** from collecting some materials;
- ›**reduce your costs** from purchasing less material and maximizing skip space;
- ›**comply** with legislation;
- ›**reduce accidents** by storing materials carefully to ensure a tidy site;
- **reduce CO2** emissions; and
- Help **conserve** natural resources.

2.16 STANDARD FOR MANAGING WASTE IN THE CONSTRUCTION SITE

There has been suggested best practice that could improve the overall standard of managing waste in the construction site (Alfreton, 2015)

- Rather than placing the onus of being responsible for waste management on a site to an individual, to ensure cooperation among site staff it would be a good idea to divide the site into several areas and assign such responsibility to a number of individuals, one for each area and gradually train all relevant members of the project team;
- Involve waste management contractors at the early stages of the project to discuss opportunities for recycling and agree high levels of recycling of waste;
- Set targets for trade contractors in relation to the following parameters: waste diverted from landfill, waste minimizations recycling rates and waste recovery rates.
- Set targets for trade contractors in relation recycled content of materials employed;
- Use clearly labelled containers optimized for segregation of specific waste streams;
- Consider the use of compacters and balers;
- Designate a reuse area within the site logistics;
- Use just-in-time delivery for materials and avoid double handling

In conclusion, construction waste is a global issue which needs serious attention since it has become environmentally unfriendly and make the environment difficult to perform its intended function. The growth in population and the quest for development such as the built environment has depleted the ozone layer , global warming, resource depletion and ecosystem destruction. This has put the built environment and the construction industry under the spotlight since its activities significantly impact on the environment. Industries, particularly the construction industry where a great deal of capital is injected in its activities requires appropriate and systematic procedures in its execution in order to meet its target and budget. .It is therefore imperative to adapt a more prudent method to meet this need particularly, in a country like Ghana where its economy is persevering to find its feet.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The research methodology adopted was to accomplish the objectives of this project. This chapter represents the data collected. It seeks to compare the concept which was highlighted in the literature review with the fact collected from field survey. The focus of this chapter is to present an in-depth descriptive plan on the processes and methods adopted in pursuance of this research, primarily on the research design, study population, study areas, sample and sampling techniques, data collection instrument, validity, reliability and finally data analysis procedure.

3.2 RESEARCH DESIGN

Research design is the overall plan for obtaining answers to the questions being studied and for handling some of the difficulties encountered during the research process (Al- Moghany, 2006; Polit and Hungler, 1999). This design was much desirable as it sought to compare many different variables and gather a pool of opinions and practices at the same time which in turn allowed the researcher to obtain a detailed inspection on the criteria for measuring the environmental performance of construction activities in Ghana. Quantitative approach with structured questionnaire was used to source data on the level of impact of construction activities on the environment during the construction process, the perceptions of practitioners (architects, quantity surveyors and structural engineers), consultants and contractors concerning the influences of construction activities on the environment in Ghana, and significant factors that influence material waste production during construction. This approach was preferable as the study been exploratory in nature yielded an outcome that was easy to summarize, compare and generalize.

The study been a two - phase design used structured questionnaire for the first phase to secure data on the impact of construction activities on the environment during the construction process, the perceptions of practitioners (architects, quantity surveyors and structural engineers), consultants and contractors concerning the influences of construction activities on the environment in Ghana, and significant factors that influence material waste production during construction.

The second phase constituted propose and validate a workable criteria for measuring the environmental performance of construction activities in Ghana using the factors that encouraged its implementation as indicated earlier which also was obtained with structured questionnaire.

3.3. POPULATION

Population is all members of a group been studied (Vorauer & Quesnel, 2016). In order to meet the research objectives, the study was conducted among construction and consulting firms in Accra and Kumasi targeting architects, contractors, project managers, civil/structural engineers, quantity surveyors and consultants mainly involved in the practice of construction activities. The target population for the data collection using the questionnaires consisted of consultancy firms (architectural and quantity surveying) and construction organizations. Building construction organizations operating within Ghana register with the Ministry of Water Resource, Works and Housing (MWRWH) in two categories: classes D and K based on the nature of work the organizations engage in - building, civil engineering construction, electrical and plumbing works as classified respectively. Project managers of D and K building and civil construction organizations who are registered with the MWRWH as well as directors of works of architectural and quantity surveying firms fully registered with the

Architects Registration Council of Ghana (ARCG) and the Ghana Institution of Surveyors (GhIS) respectively were involved in the study.

3.4. STUDY AREAS

The study was done within two geographical towns namely: Kumasi and Accra. These towns were selected due to the huge presence of foreign direct investors (China, Portugal, Brazil etc.) who virtually practice construction activities in their line of work, into the industry sector which the construction industry accounts for a greater significance in growing the economy through its contribution to Growth Domestic Product (GDP) (Ghana Statistical Service, 2015). Also capital intensive construction projects dominate these towns characterized by massive construction and infrastructure developments which will necessitate clients to engage in contemporary methods in its processes and executions. Moreover, the rate of construction works by empirical evidence are very high in these towns as people from far and near are continuously putting up structures and definitely, clients involved would require a cost effective technique in this perspective.

Figure 3. 1 Map of Ghana

Source: Ghana Statistical Service (2010).

3.4.1. Accra

The Greater Accra Region has the smallest area of Ghana's 10 managerial districts, possessing an aggregate land surface of 3,245 square kilometers or 1.4 percent of the aggregate land range of Ghana. It is the second most populated district, after the Ashanti Region, with a populace of 2,905,726 in 2000, representing 15.4 for every penny of Ghana's aggregate populace. The Greater Accra Region was a piece of the Eastern Region before 1982 and Greater Accra district was made from the Eastern Region in 1982 and right now harbors the seat of government in Accra.

It has been a center of many construction projects in the country at this period, from construction of recreational centers to construction of individual houses. Some of the projects been undertaken in this area are, west hills mall, Accra stadium which hosted the CAN 2008, Tetteh Quarshie Interchange, Circle Interchange and a whole lot of gargantuan projects in the country. Due to the regular construction projects and the hub of most international and domestic contractors, it would deem fit to undertake the study there.

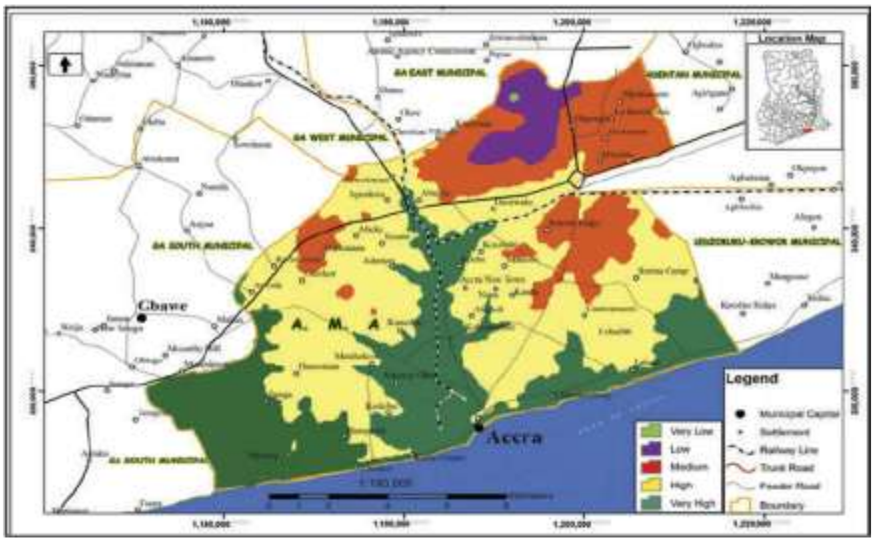

Figure 3. 2 Map of Accra Municipality

Source: Ghana Statistical Service (2010) Population and Housing Census, District Analytical Report-Accra Metropolitan

3.4.2. Kumasi

Kumasi (historically spelled Comassie or Coomassie) is a city in Ashanti, South Ghana. Kumasi is located near Lake Bosomtwi, in a Rain Forest region, and is the commercial, industrial and cultural capital of Asanteman. Kumasi is approximately 300 miles (480 km) north of the Equator and 100 miles (160 km) north of the Gulf of Guinea. Kumasi is known as "The Garden City" because of its many beautiful species of flowers and plants. Kumasi has a population of 2,069,350 people.

It is the second most developed area in Ghana having seen the likes of the refurbishment of Kumasi Sports stadium, Sofoline Interchange, KNUST Jubilee Shopping mall, KNUST overhead pass, ongoing Kumasi City mall, etc. Kumasi been one of the most developed places in the country and was chosen due to the high anticipation of construction works.

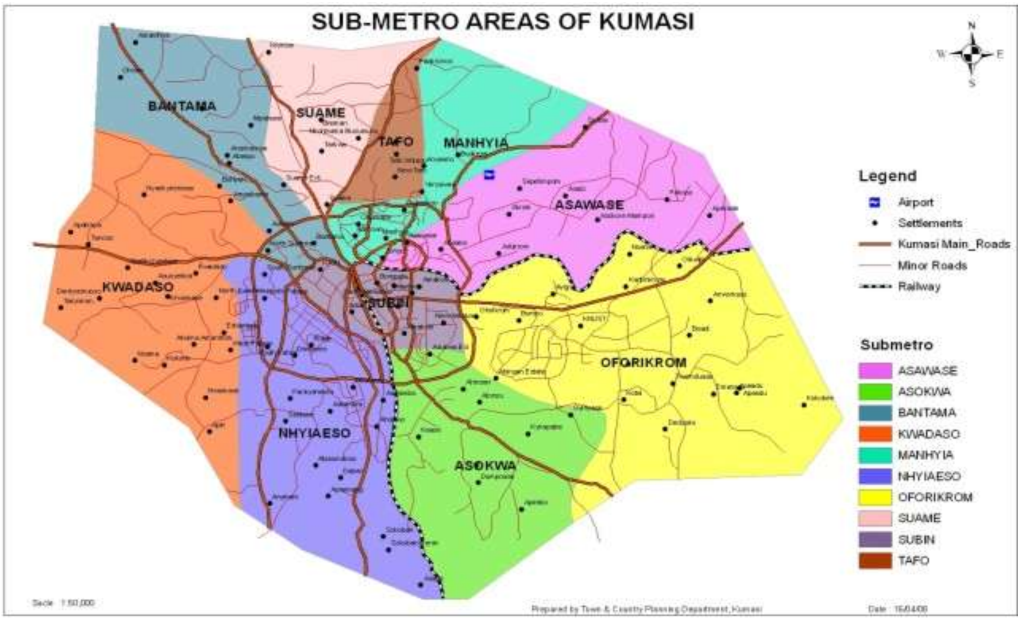

Figure 3.3 Map of Kumasi

Source: Ghana Statistical Service (2010) Population and Housing Census, District Analytical Report-Kumasi Metropolita

3.5 Sources of data

The study depended on both primary and secondary data. Primary data was made up of first-hand data collected by the candidate through the use of questionnaires, interviews and site visits (observation). The secondary sources of data were obtained using relevant books, journals, magazines and research papers.

3.6 Research Instrument

The research data was collected mainly through interviews and questionnaires. Field observations through site visits were also employed to gather data on high waste generating building materials.

3.6.1. Questionnaire Design

The questionnaire, which consisted of 3 major sets of closed-ended questions was designed to obtain data on the major impact of construction activities on the environment during the construction process, the questionnaire further sought to obtain information on the perceptions of construction experts (structural engineers, architects and quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana.

Structure of questionnaire

The questions were constructed using the Likert scale. The respondents were asked to rank on a scale of 1-5 the major impact of construction activities on the environment during the construction process where 5 = Strongly Agree 4 = Agree 3 = Neutral 2 = Disagree 1 = Strongly Disagree. For the perceptions of construction experts (structural engineers, architects and quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana on the Likert scale of 1 to 5 where 5 = Strongly Agree 4 = Agree 3 = Neutral 2 = Disagree 1 = Strongly Disagree

The respondents were further asked to score each measure according to the level of practice in their organization on a scale of 1 to 5 where 5= Highly Influential, 4= Influential, 3= Neutral, 2= Less influential 1= Not Influential.

3.7 Target Population

The target population for the data collection using the questionnaires consisted of consultancy firms (architectural, quantity surveying and civil engineer) and construction organizations. Building construction organizations operating within Ghana register with the Ministry of Water Resource, Works and Housing (MWRWH) in categories D, based on the nature of work the organizations engage in There are four financial sub-classifications within these categories - Class 1, 2, 3 and 4 - which set the limitations for companies in respect of their asset, plant and labour holdings, and the nature and size of the projects they can undertake. Class 1 has the highest resource base, decreasing through classes 2 and 3, to class 4 having the least resource base (MWRWH, 2011). Project managers of D1 building construction organizations who are registered with the MWRWH as well as directors of works of architectural and quantity surveying firms fully registered with the Architects Registration Council of Ghana (ARCG) and the Ghana Institution of Surveyors (GhIS) respectively were involved in the study.

3.8 Sampling procedure

The sample size of D1 construction organization was determined using the following formula recommended for such studies by Israel (1992).

n= Where n is the sample size, N is the population size and e is the desired level of precision (±5%) at 95% confidence interval. The MWRWH (2011) records on fully registered construction industries in Ghana indicate that there are 139 practitioners registered with their professional bodies in the Ashanti and Greater Accra Regions of

Ghana was determined for the questionnaire survey using the formula proposed by Yamane (1967) as follows: n= N/1+N (e) ^{2}, Where N = the total population size; e = the standard error of sampling distribution assumed to be 0.05 and n is the sample size.

The sample size was arrived at on the basis of the following statistical formula for calculating the sample size of a finite population: This brings the total population size of D1 construction organizations to 139. Therefore N= 139.

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

N = Estimated population size of the studied = 139

n = Sample size

e = level of significance (0.05)

n = 139 ⁄ {1+ 139(0.05)^2}

n = 103.2

n= = 103 building construction organizations

As a result, 103 building construction organizations were considered. All 103 fully registered architectural firms and quantity surveying firms in Kumasi and Accra

A total of 103 questionnaires were personally distributed by the researchers to respondents in the Greater Accra Region and Kumasi of Ghana where the concentration of practitioners is high. In total, (80) questionnaires (77.7%) were retrieved from the respondents for analysis. In the same second stage, semi-structured interviews were also conducted amongst some contractors and consultants for the qualitative study. The interviews adopted an attitudinal approach which is used to subjectively evaluate the opinion of a person or a group of people towards a particular attribute, variable, factor or a question.

The choice of construction organizations was due to lack of reliable information on small scale firms, and also based on the assumption that large and well-established firms have good organizational set up. A simple random sampling approach was used to select the total number of (103) firms for the study. In this approach, every unit had an equal chance of selection (Hoe, 2006).

3.9 VALIDATION OF INSTRUMENT

Validity is the extent to which an instrument accurately measures what is supposed to measure (Frisby et al., 2014). To ensure the accuracy of information, the questionnaire was given to the supervisor whose recommendation upon thorough scrutiny was used to formulate the instrument that had the ability to obtain the expected relevant data. After the design, a pilot study was conducted among two experts who have experience in the practice of value engineering in the Ghanaian construction industry. They were made to assess the comprehensiveness of all the items in the questionnaire for clarity and appropriateness on the feasibility of implementing value engineering in the Ghanaian construction industry. The experts were allowed to exclude unimportant factors and add factors they perceived necessary. The questionnaire was subjected to rating and the content validity index (CVI) computed using the formula;

Average of CVI=number of items rated valid/all items in questionnaire. A value of 0.96 obtained met the recommended validity of 0.7 as suggested by Amin (2005), which rendered the questionnaire valid for data to be collected. Content validity refers to how accurately an assessment or measurement tool taps into the various aspects of the specific construct in question (Smith, 2005).

3.10 DATA ANALYSIS PROCEDURE

This section deals with the methods of analysis of the data. Quantitative and qualitative methods were adopted to evaluate the data. The results were calculated into percentages and finally presented in the form of tables. Descriptive statistical analysis was used based on computer data analyses software such as the use of Statistical Package for Social Sciences (SPSS) version 20 Microsoft excel to help come out with the results. The reason for the selection of these programs was that, this technique enhances word processing and data analysis very easy and accurate pictorial presentations. The other questions that were open-ended were analyzed by listing all the important responses given by the respondents. The responses were considered based on the relevance to the study. This gave the general idea of the study with respect to the criteria for measuring the environmental performance of construction activities in Ghana. Also inferential statistics such as relative importance index method (RII) was used herein to determine architects, quantity surveyors, and structural engineers' perceptions of the relative importance of the identified environmental impacts of construction activities.

3.10.1. Perceptions of construction experts (structural engineers, architects and quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana.

Data obtained from the study were ranked using the Relative Importance Index Analysis.

The questions which required respondents to rank options were analysed using the Relative Importance Index method (Olugboyega 1997). The formula states as follows:

Relative Importance Index = EW/ (S x N)

Where, EW = the summation of the weighting given to each factor, where the weighting is the product of score and the number of respondents, ranging from 1 to 5.

S = Maximum score (i.e. 5 in the study)

N = Total number of firms surveyed (total number of samples)

Ranking of the success criteria using evidence from the ratings were however done using Relative Important Index (RII) and the criterion with the highest (RII) emerged first followed by the second highest, in that order for parts two (2), three (3) and four (4) of the structured questionnaire

In conclusion research methodology used in this study was discussed as above. A description of how the questionnaire was administered and the various sections in the questionnaire were emphasized. Eventually, the statistical tools for data analysis were discussed. With this background, statistical results obtained from the data are discussed in chapter four.

CHAPTER FOUR

ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

This chapter contains the description of results analyzed from the data collected for this survey. After the questionnaire survey was carried out, statistical analyses were undertaken on the responses using various approaches described in the research methodology. The layout of this chapter is in accordance with the objectives of this study. The demographic characteristics of respondents form the first part. The second part bears on the result obtained from respondent's views on the major impact of construction activities on the environment during the construction process which also is contained in the first objective. Results on the perceptions of construction experts (structural engineers, architects and quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana which constitute the second objective is presented in the third part. The fourth part constitutes the results achieved from factors that influence material waste production during construction.

then again summing up the third objective with the last part which settles on to propose and validate a workable criteria for measuring the environmental performance of construction activities in Ghana also concluding the fourth objective

4.2 DEMOGRAPHIC CHARACTERISTICS

Table 4.1 provides information on the demographic characteristics of respondents used in the survey. It focuses on the respondent's academic background, professional background, relativeness of their job to the construction industry and work experience.

Table 4. 1 Demographic characteristics of respondents

Characteristics	Categories/options	Frequency	Percentage
Profession	Architect	15	18.8
	Civil/ Structural Engineer	16	20.0
	Project Manager	25	31.3
	Quantity surveyor	14	17.5
	Contractor	10	12.5
Occupation relative to industry	General consultancy	31	38.8
	Architectural consultancy	15	18.8
	Quantity surveying firm	24	30.0
	Civil / Structural engineering consultancy	10	12.5
Education	BSc. Honors	40	50.0
	PG Diploma	20	25.0
	MSc/MEng	15	18.8
	M.Phil.	3	3.8
	PhD	2	2.5
Work Experience	5 years or less	18	18.8
	6 – 10 years	25	31.3
	11 – 15 years	22	27.5
	Above 15 years	15	22.5

(field survey, 2018)

BSc. Honours came up as the highest academic qualification of the respondents (50.0%), followed by PG Diploma and MSc/MEng sharing each with (25%) and (18.8%) respectively as M.Phil. Only made (3.8%), PhD was the least with (2.5%) . In terms of professional background, about quarter of the respondents were Project Manager (31.3%) with Civil/ Structural Engineer (20.0%) coming next, and then Architect (18.8%),
Quantity surveyor (17.5%) and Contractor (12.5%) following in a logical manner. Also, the respondent's occupation relative to the construction industry had General consultancy, Quantity surveying consultancy firm, Architectural consultancy and Civil/structural engineering consultancy accounting for 38.8%, 30.0%, 18.8% and 12.5% respectively. With regards to work experience, respondents who were 6-10 years totaled 31.3% and 11-15 years were also 27.5% with those who were 5 years or less just recording 18.8%.

4.3 ASSESS THE MAJOR IMPACT OF CONSTRUCTION ACTIVITIES ON THE ENVIRONMENT DURING THE CONSTRUCTION PROCESS.

In the quest to assess the major impact of construction activities on the environment during the construction process , the variables coined from the questionnaire were subjected to a Mean relative analysis. The outcome in Table 4.2 shows weight and rank obtained by each item dependent on the ratings obtained by each using Mean Relative Analysis to access variables that impact on the environment during the construction process on a 5-point scale from strongly agree to strongly disagree.

Table 4. 2 Ranking of variables on the major impact of construction activities on the environment during the construction process.

SN	Factors	1	2	3	4	5	Total	∑W	Mean	Rank
1	Consumption of large amounts of energy during the processing of materials, construction processes and in the use of constructed structures	2	4	4	38	32	80	334	4.175	1
2	Dust and gas emission released during the production and transportation of materials.	4	6	10	35	25	80	311	3.8875	2
3	Disruption of people living in the vicinity of construction projects through traffic diversion, noise pollution and others	4	9	12	28	27	80	305	3.8125	3
4	Production of substantial volumes of waste	0	13	11	36	20	80	303	3.7875	4
5	Waste water discharge	7	13	11	20	29	80	291	3.6375	5
6	Damage to public drainage systems	4	12	12	37	15	80	287	3.5875	6
7	Pollution from building materials	6	11	9	39	15	80	286	3.575	7
8	Substantial consumption of both renewable and non-renewable resources	7	9	12	37	15	80	284	3.55	8
9	Human health issues.	11	11	10	30	18	80	273	3.4125	9
10	Traffic increase and parking space shortage	11	12	11	24	22	80	270	3.375	10

(field survey, 2018)

Clearly presented in the results, it is observed that the top five items that distinguished themselves as the most important factors that impact on the environment during the construction process included; consumption of large amounts of energy during the processing of materials, construction processes and in the use of constructed structures, dust and gas emission released during the production and transportation of materials, disruption of people living in the vicinity of construction projects through traffic diversion, noise pollution and others, Production of substantial volumes of waste and Waste water discharge. Accordingly, consumption of large amounts of energy during the processing of materials, construction processes and in the use of constructed structures was the most important factor that impact the environment during construction process with mean value of 4.175 and ranked first. Next most important factor was dust and gas emission released during the production and transportation of materials getting a mean value of 3.8875 and placing second on the rank. Disruption of people living in the vicinity of construction projects through traffic diversion, noise pollution and others were ranked third most important factors affect the environment during construction activities securing mean value of 3.8125. other major factors which impact the environment during construction are production of substantial volumes of waste and Waste water discharge obtaining the mean mark of 3.7875 and 3.6375 respectively.

Inversely, the least important factor the impact of construction activities on the environment during the construction process was traffic increase and parking space shortage which had a mean value of 3.375.

4.4 The perceptions of construction experts (structural engineers, architects and quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana.

In an attempt to determine the perceptions of construction experts (structural engineers, architects and quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana, the variables created from the questionnaire were subjected to a Relative Importance Index analysis. The outcome in Table 4.2 shows weight and rank obtained by each item dependent on the ratings obtained by each using Mean Relative Analysis to identify the perceptions of construction professionals concerning the influences of construction activities on the environment in Ghana on a 5-point scale from strongly agree to strongly disagree.

4.3.1 Structural engineers point of view concerning the influences of construction activities on the environment in Ghana

Table 4.3 : Ranking of the perceptions of construction experts using Relative Importance Index (RII)

	RATING									
PARAMETERS	**1**	**2**	**3**	**4**	**5**	**TOTAL**	**∑W**	**MEAN**	**RII**	**RANKING**
A. Resource consumption										
1. Electricity consumption	3	5	7	9	6	80	286	3.575	0.715	8
2. Water consumption	3	6	5	11	5	80	265	3.3125	0.663	12
3. Raw materials consumption	2	4	4	12	8	80	334	4.175	0.832	1
4. Fuel consumption	3	5	2	12	8	30	303	3.7875	0.758	4
B. Waste generation										
1. Ordinary waste	0	13	11	36	20	80	303	3.7875	0.758	4
2. Inert waste	7	13	11	20	29	80	291	3.6375	0.728	6
3. toxic waste	4	12	12	37	15	80	287	3.5875	0.718	7
4. excavated waste material	15	14	14	25	12	80	245	3.0625	0.613	16
C. Atmospheric emissions										
1. Emission of Chlorofluorocarbon	11	12	11	24	22	80	270	3.375	0.675	11
2. Greenhouse gas emissions	4	6	10	35	25	80	311	3.8875	0.778	2

D. Water emissions										
1. Water from excavation	7	9	12	37	15	80	284	3.55	0.71	9
2. Water from cleaning tools	22	20	10	19	9	80	213	2.6625	0.533	18
E.Soil alteration										
1. Concrete release agent	11	11	10	30	18	80	273	3.4125	0.683	10
2. Cleaning agents	44	21	8	2	5	80	143	1.7875	0.358	23
3. construction machinery waste	34	19	11	7	9	80	178	2.225	0.445	22
F. Local issues										
1. Dust generation from machinery	4	17	26	24	9	80	257	3.2125	0.643	15
2. Dust generation in earthworks	4	7	10	30	29	80	202	2.525	0.505	19
3. Dust generation in cutting operations	26	23	15	10	6	80	187	2.3375	0.468	21
G. Effects of biodiversity										
1.Potential soil erosion	18	18	17	16	11	80	224	2.8	0.56	17
2. Loss of structure and composition of soil	27	24	9	11	9	80	191	2.3875	0.478	20
3. Vegetation removal	7	17	13	30	13	80	265	3.3123	0.663	12
4. Intervention of water bodies	4	17	26	21	12	80	260	3.25	0.65	14
5. Interference with the ecosystems	4	9	12	28	27	80	305	3.8125	0.763	3

(field survey, 2018)

4.4.2 Architectural point of view concerning the influences of construction activities on the environment in Ghana

Table 4.4 : Ranking of the perceptions of construction experts using Relative Importance Index (RII

	RATING									
PARAMETERS	**1**	**2**	**3**	**4**	**5**	**TOTAL**	**∑W**	**MEAN**	**RII**	**RANKING**
A. Resource consumption										
1. Electricity consumption	6	11	9	39	15	80	286	3.575	0.715	8
2. Water consumption	7	17	13	30	13	80	265	3.3125	0.663	12
3. Raw materials consumption	2	4	4	38	32	80	334	4.175	0.832	1
4. Fuel consumption	3	11	6	40	20	80	303	3.7875	0.758	4
B. Waste generation										
1. Ordinary waste	0	13	11	36	20	80	303	3.7875	0.758	4
2. Inert waste	7	13	11	20	29	80	291	3.6375	0.728	6
3. toxic waste	4	12	12	37	15	80	287	3.5875	0.718	7
4. excavated waste material	15	14	14	25	12	80	245	3.0625	0.613	16
C. Atmospheric emissions										
1. Emission of Chlorofluorocarbon	11	12	11	24	22	80	270	3.375	0.675	11
2. Greenhouse gas emissions	4	6	10	35	25	80	311	3.8875	0.778	2
D. Water emissions										
1. Water from excavation	7	9	12	37	15	80	284	3.55	0.71	9
2. Water from cleaning tools	22	20	10	19	9	80	213	2.6625	0.533	18
E.Soil alteration										
1. Concrete release agent	11	11	10	30	18	80	273	3.4125	0.683	10
2. Cleaning agents	44	21	8	2	5	80	143	1.7875	0.358	23

3. construction machinery waste	34	19	11	7	9	80	178	2.225	0.445	22
F. Local issues										
1. Dust generation from machinery	4	17	26	24	9	80	257	3.2125	0.643	15
2. Dust generation in earthworks	4	7	10	30	29	80	202	2.525	0.505	19
3. Dust generation in cutting operations	26	23	15	10	6	80	187	2.3375	0.468	21
G. Effects of biodiversity										
1.Potential soil erosion	18	18	17	16	11	80	224	2.8	0.56	17
2. Loss of structure and composition of soil	27	24	9	11	9	80	191	2.3875	0.478	20
3. Vegetation removal	7	17	13	30	13	80	265	3.3123	0.663	12
4. Intervention of water bodies	4	17	26	21	12	80	260	3.25	0.65	14
5. Interference with the ecosystems	4	9	12	28	27	80	305	3.8125	0.763	3

(field survey, 2018)

4.4.3 Quantity surveyors point of view concerning the influences of construction activities on the environment in Ghana

Table 4.5: Ranking of the perceptions of construction experts using Relative Importance Index (RII

	RATING									
PARAMETERS	**1**	**2**	**3**	**4**	**5**	**TOTAL**	**∑W**	**MEAN**	**RII**	**RANKING**
A. Resource consumption										
1. Electricity consumption	6	11	9	39	15	80	286	3.575	0.715	8
2. Water consumption	7	17	13	30	13	80	265	3.3125	0.663	12
3. Raw materials consumption	2	4	4	38	32	80	334	4.175	0.832	1
4. Fuel consumption	3	11	6	40	20	80	303	3.7875	0.758	4
B. Waste generation										
1. Ordinary waste	0	13	11	36	20	80	303	3.7875	0.758	4
2. Inert waste	7	13	11	20	29	80	291	3.6375	0.728	6
3. toxic waste	4	12	12	37	15	80	287	3.5875	0.718	7
4. excavated waste material	15	14	14	25	12	80	245	3.0625	0.613	16
C. Atmospheric emissions										
1. Emission of Chlorofluorocarbon	11	12	11	24	22	80	270	3.375	0.675	11
2. Greenhouse gas emissions	4	6	10	35	25	80	311	3.8875	0.778	2
D. Water emissions										
1. Water from excavation	7	9	12	37	15	80	284	3.55	0.71	9
2. Water from cleaning tools	22	20	10	19	9	80	213	2.6625	0.533	18
E.Soil alteration										
1. Concrete release agent	11	11	10	30	18	80	273	3.4125	0.683	10
2. Cleaning agents	44	21	8	2	5	80	143	1.7875	0.358	23
3. construction machinery waste	34	19	11	7	9	80	178	2.225	0.445	22
F. Local issues										
1. Dust generation from machinery	4	17	26	24	9	80	257	3.2125	0.643	15
2. Dust generation in	4	7	10	30	29	80	202	2.525	0.505	19

earthworks										
3. Dust generation in cutting operations	26	23	15	10	6	80	187	2.3375	0.468	21
G. Effects of biodiversity										
1.Potential soil erosion	18	18	17	16	11	80	224	2.8	0.560	17
2. Loss of structure and composition of soil	27	24	9	11	9	80	191	2.3875	0.478	20
3. Vegetation removal	7	17	13	30	13	80	265	3.3123	0.663	12
4. Intervention of water bodies	4	17	26	21	12	80	260	3.25	0.650	14
5. Interference with the ecosystems	4	9	12	28	27	80	305	3.8125	0.763	3

(field survey,2018)

Raw materials consumption

The table above clearly justify the perception the three groups namely Structural engineer Architect and Quantity surveyors on the influences of construction activities on the environment in Ghana. All the three tables enunciated that resource consumption group of environmental impacts was ranked highest by all the respondents. **Raw materials consumption** was determined by all respondents under the resource consumption group of environmental impacts as the 1st principal environmental impact of construction activities in Ghana.

It is expedient take into consideration that other expert group like contractors and consultants interviewed revealed that raw materials consumption is the most critical environmental impact with the relative importance index of 0.832.

In the literature it was stated that, the Austrian construction industry has about 50 percent of material turnover induced by the society as a whole per year (Rohracher, 2001) and 44 percent in Sweden (Sterner, 2002). Inversely, electricity consumption (0.715) and fuel consumption(0.758) cannot be left out as it being by considered by critics as part of those influential factor and were ranked within the top ten most important environmental impacts of construction activities in Ghana whereas water consumption was considered less influential factor with relative importance index of 0.663.

Atmospheric emissions.

The atmospheric emissions group of environmental impacts was ranked second by all the respondents, which occurs when harmful of excessive quantities of substances including gases, particles and biological molecules are introduce into the earth. According to the three construction groups namely Quantity Surveyors and Structural Engineers Architects, Greenhouse gas emissions and chlorofluorocarbons (CFCs) was a major environmental impact which has seriously depleted the ozone layer according to (Langford et al., 1999). Greenhouse gas emissions and Emission of Chlorofluorocarbon was ranked 2nd and 11th with the relative importance index of 0.778 and 0.675 respectively.

Biodiversity.

Views from the three construction groups were expressed concerning the influence of construction activities on the environment in Ghana. The effects on biodiversity group were ranked the third most important environmental impact of construction activities by the three groups of respondents. Interference with the ecosystem was the most strongly agreed environmental factor which affect biodiversity with the relative importance of 0.763 on the tables shown above. Other factors which also influence biodiversity are vegetable removal (0.663) ranked 12th , intervention of water bodies (0.650) ranked 14th, potential soil erosion was ranked 17th with the relative importance index of 0.560 and the least influential factor under the biodiversity was loss of structure and composition of soil with RII of 0.478.The effects of biodiversity has call for customized regulation to the construction processes and for this reason an exhaustive preliminary analysis with a process oriented approach (Zobel & Burman, 2004).

Waste generation

According to respondent, the three groups of construction professional express the views the waste generation greatly influence impact the environment during construction process. Ordinary waste, inert waste and toxic waste are the major factors which influence waste generation. According to the table their rank and RII are, . Ordinary waste 4th (0.758) , inert waste 6th (0.728) and toxic waste 7th (0.718) with excavated material being the least which was ranked 16th with RII (0.613). According to Ofori and Chan (1998) majority of the wastes generated from construction activities resulted from the production, transportation and the use of materials.

Water emissions

The water emissions group was ranked the lowest by the three groups of respondents (Structural engineers, Architect and the Quantity surveyors). Concerning all the factors in the group, all three parties ranked water from excavation high with relative importance index of 0.710. As indicated by the respondents, water emissions from cleansing tools do not impact the environment so much in Ghana.

Local issues

Structural engineers Architects and, Quantity surveyors together stress on the factors such as dust generation from machinery, dust generation in earthworks and dust generation in cutting operations as other factors influencing construction waste. These factors are ranked with the relative importance index of 0.643, 0.505 and 0.468 respectively. Local issues group as the third most crucial environmental impact of construction activities was ranked as the least influential factor.

Soil alteration

The three groups of respondents together ranked concrete release agent during construction activities as the tenth most essential environmental impact of construction activities. Soil alteration as an environmental impact group was ranked relatively low. All parties agreed that construction machinery waste and cleansing agent were the least factor affecting soil variation.

The three construction professional (Structural engineer, Architect and Quantity surveyors plays an indispensable role when it comes to construction project execution. They clearly justified according to the table that raw material consumption greatly impact the environment during construction activities and was ranked the first influential factor by all the three groups of construction industry. Water consumption, electricity and fuel consumption which are all under the resource consumption group of environmental impacts were ranked within the top ten most important environmental impacts of construction activities in Ghana.

The three groups ideas are a bit similar with a slight different in though as they are wholly classified as practitioners when it comes to project execution.

4.5 FACTORS THAT INFLUENCE MATERIAL WASTE PRODUCTION DURING CONSTRUCTION

Table 4. 6 **Ranking of variables on the factors that influence material waste production during construction**

SN	Factors	MEAN SCORE OF WASTE	STANDARD DEVIATION	RANKING
	PROCUREMENT WASTE			
	Delivery methods	4.00	1.282	1
	No take back schemes	3.95	1.262	2
	Poor supply chain management	3.68	1.111	3
	Poor advice from suppliers	3.38	1.236	4
	Poor quality of materials	3.10	1.373	5
	Delivery schedules	2.48	1.350	6
	Purchase of inadequate materials	2.20	0.960	7
	MATERIAL HANDLING WASTE			
	Poor product knowledge	3.760	1.343	1
	Inappropriate handling	3.750	1.207	2
	Inappropriate storage	3.660	1.302	3
	Damages due to transportation	2.540	1.242	4
	OPERATION WASTE			
	Inclement weather	2.840	1.418	1
	Rework, variation and negligence	3.470	1.387	2
	Poor communication	3.550	1.386	3
	Poor coordination between trades	3.750	1.373	4
	Time restraint	2.480	1.312	5

	Unskilled labour	3.690	1.298	6
	CULTURE			
	Lack of training	3.480	1.368	1
	Lack of awareness	3.66	1.321	2
	Lack of incentives	3.430	1.320	3
	Lack of support from senior management	3.980	1.303	4

(field survey, 2018)

4.6 FACTORS ACCOUNTING FOR WASTE ON CONSTRUCTION SITE

Factor that account for wastes on construction site have been categorized into four main parts namely, procurement waste, material handling waste, operation waste and culture attitude.

- Wastes generating from procurement factors on construction sites were assessed by respondents from construction field. From the table above delivery methods, no take back scheme, Poor advice from suppliers and Poor advice from suppliers are the main factors that influence material waste production during construction. poor quality of materials delivery schedules purchase of inadequate materials were considered the least factors according to the respondent
- Material handling (Damages during transportation, inappropriate storage, materials supplied in loose form, use of whatever material which are closed to working place, unfriendly attitude of project team and labourers, theft). From table 4.6 it was revealed that, Poor product knowledge, inappropriate handling and inappropriate storage are the major influential factor accounted for waste generation on the construction site. This was further explain by Ekanayake and Ofori, 2000 as stated in literature.

- Opinions pulled by respondents from Table 4.6 showed a strong approval of the influence of material waste on the environment. It was revealed that Inclement weather, Rework, variation and negligence, Poor communication, Poor coordination between trades and Time restraint are seen to be the principal factors that leads to operation waste. Operational waste (errors by trade persons or labourers, accidents due to negligence, damage to work done caused by subsequent trades, use of incorrect material, required quantity unclear due to improper planning, equipment malfunctioning, inclement weather) are attributed to operation waste (Ekanayake and Ofori, 2000). Unkilled labour according to table 4.5 not seen as major influential factor.
- From the table, the attitude of most construction official also attribute to the generation of waste in the construction industry. According to the table 4.6 Lack of training, awareness are the top factors which are considered as human attitude that account for waste production during construction.

  In conclusion, construction industry plays a significant role in the economy of every nation. However, generation of waste in this industry is quite enormous. Discovering their cause, source and their negative repercussion on the environment will go a long way so the necessary steps can be adopted to curb before it gets out of hand.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION:

This research executed a survey to explore criteria for measuring the environmental performance of construction activities in Ghana . This appraisal was made manifest through clearly defined and specified objectives that formed the basis of the study. These were, assess the major impact of construction activities on the environment during the construction process, determine the perceptions of construction experts (structural engineers, architects and quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana, determine the most significant factors that influence material waste production during construction Data was collected through field survey from the respective respondents. Below are the findings under each specific objective accordingly.

5.1.1 Assess the major impact of construction activities on the environment during the construction process.

The study stressed on ten factors that have impact of construction activities on the environment during the construction process among construction practitioners in Ghana. It is observed that the top five items that distinguished themselves as the most important factors that impact on the environment during the construction process included; consumption of large amounts of energy during the processing of materials, construction processes and in the use of constructed structures, dust and gas emission released during the production and transportation of materials, disruption of people living in the vicinity of construction projects through traffic diversion, noise pollution and others, Production of substantial volumes of waste and Waste water discharge. The least important factor that have impact of construction activities on the environment during the construction process was highlighted, that is traffic increase and parking space shortage.

5.1.2 The perceptions of construction experts (structural engineers, architects and quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana.

An exploration was sought to determine the perceptions of construction experts (structural engineers, architects and quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana, the variables created from the questionnaire were subjected to a Relative Importance Index analysis. Analysis was to identify the perceptions of construction professionals concerning the influences of construction activities on the environment in Ghana on a 5-point scale from strongly agree to strongly disagree. In total, 23 factors were identified. Ranking them according to their mean and weight. Raw materials consumption, atmospheric emissions, biodiversity, waste generation, water emissions, local issues came top as the five most dominant factors that construction expert considered as having negative impact on the environment. This idea was solicited from expert group from construction industry and divergent ideas was expressed and some of the views were similar while others also differ slightly.

5.1.3 Factors that influence material waste production during construction.

The respondents were asked to evaluate factors that influence material waste production during construction gathered from the literature and confirmed through interviews. Mean scores and rankings was used to analysed respondent views. The factors were categorized into four main parts namely, procurement waste, material handling waste, operation waste and culture attitude. Procurement waste was considered as the most influential material waste production during construction which include (delivery methods, no take back scheme, Poor advice from suppliers and Poor advice from. Also, it was revealed that, Material handling waste (Poor product knowledge, inappropriate handling and inappropriate storage) are the major influential factor accounted for waste generation on the construction site. It was discover that inclement weather, rework, variation and negligence, poor communication, poor coordination between trades and time restraint are seen to be the principal factors that leads to operation waste. operational waste.

Culture attitude like lack of training, awareness are the top factors which is considered as human attitude that account for waste production during construction.

5.3 RECOMMENDATIONS

Based on the findings and discussions of the study, the following recommendations were put out:

1. Awareness creation must be intensified by practitioners or experts of this service in the country to our domestic industry. Enlightening them will afford people the opportunity to accept, support and participate actively in its implementation in the construction industry. Equally organising workshops, seminars and training both to clients and practitioners will help them realize the significance and benefits of safeguarding the environment.
2. The national building regulations should be reviewed to take into consideration of environmental regulations. Similarly, all forms of construction activities should be subjected to an environmental impact assessment to determine the potential impacts and also come up with some measures before they are executed.

3. There be adoption of suitable site and waste management procedures, and preparation of accurate specification for materials are suggested measures to adopt in the pursuit to minimize materials waste in construction

4. Construction authorities and regulators should engage practitioners in exchange programs with countries well advanced in the use of suitable methodology to reduce the consumption of natural resources and the environment for future generation.

5.4 LIMITATION AND RECOMMENDATIONS FOR FUTURE RESEARCH STUDIES

Construction firms and consultancies practicing in the study areas were very difficult to locate owing to their limited number. It is suggested that the areas of study should be extended to construction firms and consultancies in other areas.

The following areas are recommended for further study:

1. Recognising the impact and need adopt proper waste management approach in improving the management style used in the construction industry.
2. Roles of construction practitioners in ensuring environmental sustainability in the construction industry.
3. Assessing the reality of construction waste management on building projects as applied to the Ghanaian construction industry.

REFERENCES

Agyekum, K. (2012). Minimizing materials wastage at the construction stage of a project through the implementation of lean construction. Kumasi, Ghana: Kwame Nkrumah University of Science and Technology;

Ahmad Che,A., Husin, N. I., Zainol H., Abdul Tharim A. H., Ismail N . A., and Ab Wahid A. M., (2014)"The Construction Solid Waste Minimization Practices Among Malaysian Contractors," *Matec Web Conf.*, Vol. 15, P. 01037.

Ahmed, K., Hatira, L. and Valva, P. (2014). The Construction Industry in Ghana, West Africa. *"How can the construction industry in Ghana become sustainable?"*. Thesis submitted for completion of Master of Strategic Leadership towards Sustainability, Blekinge Institute of Technology, Karlskrona, Sweden, pp.4-5.

Ahmed, R. (2012). "Construction and the Environment". Public Commission for the Protection of Marine Resources, Environment & Wildlife, Kingdom of Bahrain.

Alarcon, L F (1993). Modelling waste and performance in construction. in *Alarcon, L. (Ed.) Lean Construction*,

Ali H. , Eeda N and Siong H. C. (2012). "Urban Solid Waste Minimisation In Malaysia - The Case Of Shah Alam City Hall , Selangor .," Pp. 1–14.

Armanda, C. (2002). *Environmental impact of construction sites in historic cities centres*, Unpublished MSc dissertation, University of Minho.

Aryee, B. (2001). Ghana's mining sector: its contribution to the national economy. *Resources Policy*, 27(2), pp.61-75.

Asif M., Muneer T. and Kelley R. (2007), Life cycle assessment: A case study of a dwelling home in Scotland. Building and Environment, 42(3): 1391-1394.

Attitude and behaviour factors in waste management in the construction industry of Malaysia.

Awad. S. (2001) analyzed the variation orders of twelve combined sewer overflow projects and found that variation orders … **Journal** of Civil Engineering and Management, 2010, 16(4): 540–551

Ball J. (2002), Can ISO 14000 and eco-labelling turn the construction industry green? Building and Environment, 37(4):421-428

Bossink, B A G, and Brouwers, H J H (1996) Construction waste: quantification and source evolution. *Journal of Construction Engineering Management*, **122**(1), 55–60.

Bunge. M. (1983). "Modelling of User activities in building design; Published in Architectural information management. Preceeding of the 19th Conference on Education in Computer Aided Architectural Design in Europe, Helsinki 2001.

Cardoso J.M. (2005). Construction site environmental impact in civil engineering education. European *Journal of Engineering Education,* 30(1), pp. 51-58.

Chang Y., Ries R.J. and Wang Y. (2011), The quantification of the embodied impacts of construction projects on energy, environment, and society based on I- O LCA. Energy Policy, 39(10), 6321-6330.

Chen Z., Li H. & Wong C.T.C. (2000). Environmental management of urban construction projects in China. *Journal of Construction Engineering and Management*, 126(4), pp. 320-324.

Chen Z., Li H. & Wong C.T.C. (2005). Environmental Planning: Analytic network process model for environmentally conscious construction planning. *Journal of Construction Engineering and Management*, 131(1), pp. 92-101.

Chen Z., Li H., Hong J. (2004), An integrative methodology for environmental management in construction. Automation in Construction, 13(5): 621- 628.

CIB Publication 237 (2001) *Agenda 21 for Sustainable Construction in Developing Countries,* First Discussion Document, Version 2

City of Huntsville Urban Forestry Section. 2000. *Managing Trees on Construction Sites*. [http://www.ci.huntsville.al.us/Landscape/Trees/UFSubpageConstruction.htm].

Civil and Environmental Research. Vol.6, No.3: 6-16. California Integrated Waste Management Board, (2003), *Rebuilding Green*, http//:www.ciwmb.ca.gov/Green Building/ pg 2 (Accessed 21-06-2006)

Clement R.B. (1996). "Complete Guide to ISO 14000",Prentice Hall: Englewood Cliffs, NJ,.

Clough, R. (1994). 'Environmental impacts of building construction', in *Proceedings of First International Conference: Building and the Environ*ment, BRE, Watford, UK, May.

Cole R. J. (1999), Energy and greenhouse gas emissions associated with the construction of alternative structural systems. Building and Environment, 34(3): 335-348.

Cole R.J. (2000). Building environmental assessment methods: Assessing construction practices. *Construction Management and Economics,* 18(8), pp. 949-957.

Construction Time and Cost Overruns on High-Rise Projects in Indonesia. **Construction Management and Economics**, **Vol. 15**, 83-94.

Curwell, S. & Cooper, I. (1998). 'The implications of urban sustainability' in *Building Research and Information,* Vol. 26, No. 1, pp. 17–28.

Dainty, A. R. J. and Brooke, R. J. (2004), "Towards Improved Construction Waste Minimization: A Need For Improved Supply Chain Integration?," *Struct. Surv.*, Vol. 22, No. 1, Pp. 20–29.

Design-Build. Journal of Construction Engineering and Management; Pp 34-40.

Djokoto S.D., & Dadzie, J. (2013). Barriers to sustainable construction in the Ghanaian construction industry: consultants perspectives *In:* Laryea, S. and Agyepong, S. (Eds) *Procs 5th West Africa Built Environment Research (WABER) Conference,* 12-14 August 2013, Accra, Ghana, 223-234.

Du Plessis, C. D. (2002), Agenda 21 for Sustainable Construction in Developing Countries – A Discussion document

Ekanayake, L L and OFORI G (2000). Construction material waste source evaluation. Proceedings of the 2nd *Southern African Conference on Sustainable Development in the Built Environment: Strategies for a Sustainable Built Environment*, Pretoria, 2000.

Ekanayake, L L and Ofori G (2004) Building waste assessment score: design based tool. *Building and Environment*, **39,** 851–61.

Ekanayake, L.L. and Ofori, G.,2000, Construction Material Waste Source Evaluation, Proceedings of Strategies for a sustainable built environment Pretoria, (Accessed 2 August 2003), Available from: www.sustainablesettlement.co.za/event/SSBE/Proceedings/ekanyake.pdf

El-Sayegh , S.M (2008) Risk assessment and allocation in the UAE construction industry. *International Journal of Project Management*, **26,** 431–438

Emmanuel R. (2004). Estimating the environmental suitability of wall materials: preliminary results from Sri Lanka. Building and Environment, 39(10), 1253- 1261.

Environmental Protection Department (2000). Review of the Operation of Environmental Impact Assessment (EIA) Ordinance and the Continuous Improvement Measures. Environmental Assessment and Noise Division; Environmental Protection Department.

Fishbein B.K. (1998) Building for the future: strategies to reduce construction and demolition

Formoso, C T, Isatto, E L and Hirota, E H (1999) Method for waste control in the building industry. Proceedings IGLC-7, 7th *Conference of the International Group for Lean Construction*, Berkeley, CA, 26-28 July.

Gangolells M., Casals M., Gassó S., Forcada N., Roca X. and Fuertes A. (2011), Assessing concerns of interested parties when predicting the significance of environmental impacts related to the construction process of residential buildings. Building and Environment, 46(5):1023-1037.

Gangolells, M., Casals, M., Gasso, S., Forcada, N., Fuertes, A. & Roca, X. (n. d.). Identifying potential environmental impacts at the pre-construction stage. Group of Construction Research and Innovation, Department of Construction Engineering, Technical University of Catalonia, Terrassa, Spain.

Gary, J. R. (1999). *Protecting Trees from Construction Damage: A Homeowner's Guide*. University Of Minnesota – Extension service. [http://www.extension.umn.edu/distribution/housingandclothing/DK6135.html]HK: Hong Kong University Press.

Gyasi-Mensah, W. and Hu, X. (2018). Towards Developing a Green Manufacturing Environment: What is Ghana doing?. *Environmental Management and Sustainable Development*, 7(2), p.170.

Hayati .I. (2006). “Assignment of Safety level in performing Building maintenance work in Malaysia. Master Thesis, University Technology Malaysia.

Ijigah E. A., Jimoh R. A., Aruleba B. O., and Ade A. B. (2013), An assessment of environmental impacts of building construction projects. Civil and Environmental Research, 3(1): 93-105.

Kaming, P.F.; Olomolaiye, P.O.; Holt, G.D and Harris, F.C. (1997) Factors Influencing

Kaur M. and Arora S. (2012), Environment impact assessment and environment management studies for an upcoming multiplex- a Case Study. IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE), 1(4): 22-30.

Kein, A.T.T., Ofori, G. & Briffett, C. (1999). ‘ISO 14000: its relevance to the construction industry of Singapore and its potential as the next industry milestone’, in *Construction Management and Economics,* Vol. 17, pp. 449– 461.

Keys A, Baldwin A and AUSTIN S (2000) Designing to encourage waste minimisation in the construction industry. Proceedings of CIBSE National Conference, Dublin, 2000.

Koskela, L (1992) Application of the New Production Philosophy to Construction. Technical Report No. 72, CIFE,

Koskela, L (1992) Application of the New Production Philosophy to Construction. Technical Report No. 72, CIFE, Stanford University.

Lam A. L. P. (1997), A study of the development of environmental management in Hong Kong construction industry. BSc Thesis. The Hong Kong Polytechnic University.

Lam P. T. I., Chan E. H. W., Chau C. K., Poon C. S. and Chun K. P. (2011), Environmental management system vs green specifications: How do they complement each other in the construction industry? Journal of Environmental Management, 92(3):788-795.

Langston, C. & Ding, G.K.C. (1997). ‘The Planet in Crisis’, in *Sustainable practices: ESD and the construction industry*, C. Langston, (Ed.), Envirobook, NSW, pp. 13–20.

Lauwerys, R., Bernard, A., Buchet, J. and Roels, H. (1993). Assessment of the Health Impact of Environmental Exposure to Cadmium: Contribution of the Epidemiologic Studies Carried Out in Belgium. *Environmental Research*, 62(2), pp.200-206.

Lenzen M. and Treloar G.J. (2002) 'Embodied energy in buildings: wood versus concrete-reply to Börjesson and Gustavsson, Energy Policy, Vol 30, pp. 249–244.

Levin H. (1997), Systematic evaluation and assessment of building environmental performance (SEABEP), paper for presentation to "Buildings and Environment", Paris, 9-12 June, 1997.

Levin, H. (1997). ‘Systematic evaluation and assessment of building environmental performance (SEABEP)’, in *Proceedings of Second International Conference, Building and the Environment,* June, Paris, pp. 3–10.

Li X., Zhu Y. and Zhang Z. (2010), An LCA-based environmental impact assessment model for construction processes. Building and Environment, 45(3):766-775.

Lingard, H, Graham, P and Smithers, G (2000) Employee perceptions of the solid waste management system operating in a large Australian contracting organization: implications for company policy implementation. *Construction Management and Economics,* **18** (4), 383-93.

Lippiatt B. C. (1999), Selecting cost-effective green building products: BEES approach. Journal of Construction Engineering and Management, 125(6):448-55.

Love P.E.D &.Edwards D.J. (2004).”Determinants of rework in building construction projects”. Engineering Construction and Architectural Management 11940: 256-274

Love, P.E.D., 1996, Towards Concurrency and Integration in the Construction Industry, The 3rd ISPE International Conference on Current Engineering, Canada.,

M. Agung Wibowo. (2009). The Contribution of the Construction Industry to the Economy

Macozoma D. S. (2012), Construction site waste management and minimization: international report, International council for Research and Innovation in Buildings, Rotterdam. Available at http://cibworld.xs4all.nl/dl/publications/Pub278/06Construction.pdf[accessed on 1st March 2013]

Mallak, S. K. Ishak, M. B. and Mohamed A. F. (2014),. “Waste Minimization Benefits And Obstacles For Solid Industrial Wastes In Malaysia,” Vol. 8, No. 2, Pp. 43–52,

March M.C. (1992), Construction and environment: a management matrix. Chartered Builder, 4,pp.12.

McCormack M.S, Treloar G.J, Palmowski L, Crawford R.H. (2007). "Modelling direct and indirect water consumption associated with construction". Building Research and Information 35(2)

Morel J. C., Mesbah A., Oggero M. and Walker P. (2001),Building houses with local materials: means to drastically reduce the environmental impact of construction. Building and Environment, 36(10):1119-1126.

Morledge R and Jackson F. (2001). “Reducing environmental pollution caused by construction plant”, *Environmental Management and Health,* vol.12, no. 2, pp.191-206,.

Morledge R. and Jackson F. (2001), Reducing environmental pollution caused by construction plant. Environmental Management and Health, 12(2): 191-206.

of Indonesia: A Systemic Approach. Retrieved from http://eprints.undip.ac.id/387/ [Accessed of Indonesia: A Systemic Approach. Retrieved from http://eprints.undip.ac.id/387/ [Accessed

Ofori, G. Gang C. G, and Ranasinghe M, (2000). "Impact of ISO 14000 on construction enterprises in Singapore", *Construction Management and Economics*, vol.18, no. 8, pp. 935-947.

Ofori, G. & Chan, P. (1998). 'Procurement methods and contractual provisions for sustainability in construction',in *Proceedings of Construction and the Environment: CIB World Building Congress*, Gavle, 7–12 June, pp. c296.

Peng, C., Scorpio, D. and Kibert, C. (1997). Strategies for successful construction and demolition waste recycling operations. *Construction Management and Economics*, 15(1), pp.49-58.

Pittet D. and Kotak T. (2009), Environmental impact of building technologies, a comparative study in Kutch District, Gujarat State, India. Paper presented at the Ecomaterials 4, Paths towards Sustainability conference, November 2009, Bayamo, Cuba

Poon C. S., Ann T. W. and Jaillon L., (2004), 'Reducing Building Waste at Construction Sites in Hong Kong' *Construction Management & Economics*, vol. 22, issue 5, pp 461-470

Poon C. S., Yu A.T.W. and Ng L.H. (2001), On-site sorting of construction and demolition waste in Hong Kong. Resource, Conservation and Recycling, 32(2): 157-172.

Poon, C.S, Yu A.T.W and Ng, L.H (2001). "On-site sorting of construction and demolition waste in Hong Kong", *Resource, Conservation and Recycling*, vol.32, no. 2,pp.157-172,.

Popescu. M.P. (1995): Project Planning, Scheduling and control in Construction. https.//www.amazon.com

Rawshan Ara Begum, Chamhuri Siwar, Joy Jacqueline Pereira, Abdul Hamid Jaafar. (2009)

Rohracher, H. (2001). 'Managing the technological transition to sustainable construction of buildings: a sociotechnical perspective', in *Technology Analysis and Strategic Management*, Vol. 13, No. 1, pp. 137–150.

Saunders, J and Wynn, P (2004) Attitudes towards waste minimization amongst labour only sub-contractors. *Structural Survey*, **22** (3), 148 – 155.

Schexnayder C. (2014).Construction Engineering ducation:History and challenges. Journal of construction Engineering and management 137(10): 730-739

Shen L Y, Bao Q and Yip S L(2000) . Implementing Innovative Functions in Construction Project Management towards the Mission of Sustainable Environment. Proceedings of the Millennium Conference on Construction Project Management ; Pp 77-84.

Shen L.Y. & Tam V.W.Y. (2002). Implementation of environmental management in the Hong Kong construction industry. *International Journal of Project Management*, 20(7), pp. 535-543.

Shen L.Y. and Tam V.W.Y. (2002). Implementation of environmental management in the Hong Kong construction industry. *International Journal of Project Management*, 20(7), pp. 535-543.

Shen L.Y., Lu W. S., Yao H. and Wu D. H. (2005), A computer-based scoring method for measuring the environmental performance of construction activities. Automation in Construction, 14(13): 297-309.

Sjostrom, C. & Bakens, W. (1999). 'CIB Agenda 21 for sustainable construction: why how and what', in *Building Research and Information*, Vol. 27, No. 6, pp. 347–353.

Skoyles, E.R. and Skoyles, J.R.,1987, Waste prevention on site, Mitchell Publishing Ltd., London.

Songer A.D and Molenaar K.R (1997). Project Characteristics for Successful Public-Sector

Spence, R. & Mulligan, H. (1995). 'Sustainable development and the construction industry', in *Habitat International*, Vol. 19, No. 3, pp. 279–292.

Stanford University.

Stern N., Peters S., Bakhshi V., Bowen A., Cameron C., Catovsky S., Crane D., Cruickshank S., Dietz S., Edmonson N., GarbettS. L., Hamid L., Hoffman G., Ingram D., Jones B., Patmore N., Radcliffe H., Sathiyarajah R., Stock M., Taylor C., Vernon T., Wanjie H., and Zenghelis D. (2006),Stern Review: The Economics of Climate Change, HM Treasury, London.

Sterner, E. (2002). 'Green procurement of buildings: A study of Swedish clients' considerations', in *Construction Management and Economics*, Vol. 20, pp. 21–30.

Tam C. M., Vivian W. Y. and Tsui W. S. (2004), Green construction assessment for environmental management in the construction industry of Hong Kong. International Journal of Project Management, 22(7):563-71.

Teixeira, J. & Armanda, C. (2000). Construction Sites and Environment in Historic Portuguese Cities, *In CIB Symposium on Construction and Environment Theory into Practice*, 23-24 November, S. Paulo, Brazil.

Teo, M.M.M. & Loosemore, M. (2001). 'A theory of waste behaviour in the construction industry', in *Construction Management and Economics*, Vol. 19, pp. 741–751.

Treloar, G J, Guptar, H, Love, P E D and Nguyen, B (2003) An analysis of factors influencing waste minimization and use of recycled materials for the construction of residential buildings. *Management of Environmental Quality: An International Journal*, **14** (1), 134-45.

Tse R. Y. C. (2001), The implementation of EMS in construction firms: case study in Hong Kong. Journal of Environmental Assessment Policy and Management, 3(2): 177-194.

Uher, T.E. (1999). 'Absolute indicator of sustainable construction', in *Proceedings of COBRA 1999*, RICS Research Foundation, RICS, London, pp. 243–253.

UNIDO (United Nations Industrial Development Organization) (1985). The Building Materials Industry: The Sector in Figures. Sectoral Studies Series, No.16, Vol.2, Sectoral Studies Branch, Division for Sectoral Studies, (UNIDO/IS.512/ADD.1).

Waste & Resources Action Programme, (2007). Achieving Good Practice Waste Minimisation And Management.

waste in municipal projects. Retrieved 14 December 2010 from http://www.informinc.org

Watuka, J., and Aligula, E. M., (2002), Sustainable Construction Practices in the Kenyan Construction Industry: The Need for a Facilitative Regulatory Environment, *Proceedings of the CIB W107 1st International Conference: Creating a Sustainable Construction Industry in Developing Countries*, 11 – 13 November, Stellenbosch, South Africa.

Willmott, D. (2010). The Impacts of Construction and the Built Environment, pp. 1- 6

Wong W S and Chan E H W (2000). Building Hong Kong: Environmental Considerations.

WRAP (2007b) *Reducing Material Wastage in Construction*. Waste and Resources Action Programme: Banbury.

Yuan, H. (2013). Critical Management Measures Contributing to Construction Waste Management: Evidence from Construction Projects in China. *Project Management Journal*, 44(4), pp.101-112.

Zobel T. & Burman J. O. (2004). Factors of importance in identification and assessment of environmental aspects in an EMS context: Experiences in Swedish organizations. *Journal of Cleaner Production*, 12 (1), pp. 13-27.

Zolfagharian S., Nourbakhsh M., Irizarry J., Ressang A. and Gheisari M. (2012), Environmental impacts assessment on construction sites. Construction Research Congress 2012: 1750-1759.

APPENDICES

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF BUILD ENVIRONMENT

DEPARTMENT OF CONSTRUCTION AND QUANTITY SURVERYING

The series of questions in this questionnaire are designed to obtain organizational response on criteria for measuring the environmental performance of construction activities in Ghana .
Please, answer the questions that follow by ticking the appropriate option (if provided) or writing unrestrictedly for open-ended questions. Please answer all questions freely but objectively.
The information is for academic purposes only and will be treated with the strictest confidentiality.
Thank You
Yamoah Bright
(M.Sc. Construction Management, KNUST)

PART A: PARTICULARS OF RESPONDENTS (OPTIONAL) / GENERAL INFORMATION

Please answer the questions below by ticking **(**√**)** as appropriate

1. What is your academic qualification?

BSc. Honors [ ] P.G. Diploma [ ] MSc. /MEng [ ] MPhil. [ ] PhD. [ ]

2. What is your professional background?

Architect [ ] Civil/Structural Engineer [ ] Project Manager [ ] Quantity Surveyor [ ]

Contractor [ ] others, (please specify) ………………………………

3. What is your occupation relative to the construction industry?

General consultancy [ ] Architectural consultancy [ ] Quantity Surveying firm [ ]

Civil/Structural Engineering consultancy [ ] Others (please specify) ………………….

4. Number of years in the profession (work experience)?

5 years or less [ ] 6 – 10 years [ ] 11 – 15 years [ ] above 15 years [ ]

PART B: ASSESS THE MAJOR IMPACT OF CONSTRUCTION ACTIVITIES ON THE ENVIRONMENT DURING THE CONSTRUCTION PROCESS .

5. How do you assess the major impact of construction activities on the environment during the construction process.? Rank on Likert scale of 1 to 5.
Please indicate (√) the major impact of construction activities on the environment during the construction process

5 = Strongly Agree 4 = Agree 3 = Neutral 2 = Disagree 1 = Strongly Disagree

SN	**Factors**	**1**	**2**	**3**	**4**	**5**
1	Consumption of large amounts of energy during the processing of materials, construction processes and in the use of constructed structures					
2	Dust and gas emission released during the production and transportation of materials.					
3	Disruption of people living in the vicinity of construction projects through traffic diversion, noise pollution and others					
4	Production of substantial volumes of waste					
5	Waste water discharge					
6	Damage to public drainage systems					
7	Pollution from building materials					
8	Substantial consumption of both renewable and non-renewable resources					
9	Human health issues.					
	Traffic increase and parking space shortage					

PART C: THE PERCEPTIONS OF CONSTRUCTION EXPERTS (STRUCTURAL ENGINEERS, ARCHITECTS AND QUANTITY SURVEYORS), CONSULTANTS AND CONTRACTORS CONCERNING THE INFLUENCES OF CONSTRUCTION ACTIVITIES ON THE ENVIRONMENT IN GHANA

6. The following are the perceptions of construction experts (architects, quantity surveyors and structural engineers), consultants and contractors concerning the influences of construction activities on the environment in Ghana. . Using a scale of 1-5, where 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree and 1 = Strongly Disagree ; ***determine the perceptions of practitioners (structural engineers and architects, quantity surveyors), consultants and contractors concerning the influences of construction activities on the environment in Ghana by ticking (√).***

SN	ENVIRONMENTAL FACTORS	1	2	3	4	5
1	**Resource consumption**					
	electricity consumption					
	water consumption					
	raw materials consumption					
	fuel consumption					
2	**Waste generation**					
	ordinary waste					
	inert waste					
	toxic waste					
	excavated waste material					
3	**Atmospheric emissions**					
	Emission of Chlorofluorocarbon					
	Greenhouse gas emissions					
4	**Water emissions**					
	water from excavation					
	water from cleaning tools					
5	**Soil alteration**					
	concrete release agent					
	cleaning agents					
	construction machinery waste					
6	**Local issues**					

	dust generation from machinery					
	dust generation in earthworks					
	dust generation in cutting operations					
7	**Effects of biodiversity**					
	potential soil erosion					
	loss of structure and composition of soil					
	vegetation removal					
	intervention of water bodies					
	interference with the ecosystems					

PART D: FACTORS THAT INFLUENCE MATERIAL WASTE PRODUCTION DURING CONSTRUCTION

7. What factors influence material waste production during construction activities?

Please rank (√) the following factors that influence material waste production during construction activities? 1-5. 5= Highly Influential, 4= Influential, 3= Neutral, 2= Less influential 1= Not Influential.

SN	Factors	1	2	3	4	5
	PROCUREMENT WASTE					
	Delivery methods					
	Delivery schedules					
	Purchase of inadequate materials					
	Poor quality of materials					
	No take back schemes					
	Poor advice from suppliers					
	Poor supply chain management					
	MATERIAL HANDLING WASTE					
	Damages due to transportation					
	Inappropriate handling					
	Poor product knowledge					
	Inappropriate storage					
	OPERATION WASTE					
	Rework, variation and negligence					
	Unskilled labour					
	Time restraint					
	Poor communication					
	Poor coordination between trades					
	Inclement weather					
	CULTURE					
	Lack of awareness					
	Lack of incentives					
	Lack of support from senior management					
	Lack of training					

PART E: RECOMMENDATIONS FOR MEASURING THE ENVIRONMENTAL PERFORMANCE OF CONSTRUCTION ACTIVITIES IN THE GHANAIN CONSTRUCTION INDUSTRY.

8. Please add any comment(s) or suggestion(s) geared towards measuring the environmental performance of construction activities in the construction industry

……

………

Thank You!