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SPES BONA

Editorial

Welcome to the first issue of the Journal of Construction Business and Management (JCBM). It is the outcome of many months of preparation involving, reviews and counter-reviews aimed at helping students and academics get important feedback on their research and also to produce quality research articles to the research community and construction industry. The journal's ideology stems from a thinking that there is a link between business and management theory which guide construction practice and performance. This first issue, therefore, marks the beginning of significant contribution to knowledge in all areas relevant to construction practice, performance and problems within the built environment through the lens of business and management principles.

I wish to thank all authors who submitted papers for consideration in the first issue, some of which are still undergoing review to be published in subsequent issues. Also, I wish to thank members of the Editorial Board and Panel of Reviewers for their assistance, timeous feedback and comments that helped shape and improve the quality of the submitted manuscripts.

Knowledge and skills required to manage construction projects efficiently and effectively can be established through research and observation and categorized and used to educate, train and socialize construction professionals, who like other professionals should be socially responsible. It is also important that professionals are aware of the challenges in the project environment. Fittingly, we publish in this issue five papers that look at sustainability, construction management, practice and performance within the built environment. The scholarly articles report the role of management in changing the perception of workers regarding Health and Safety on construction sites; managing the factors responsible for changes in building construction costs; identifying critical success factors that determine the performance outcome of building maintenance projects; evaluating the coastal hazards, risks and environmental challenges to urban development from the dynamics of a Peninsula; and an approach for relating material waste to cost overrun at the pre-contract and post-contract stages of a project. I encourage you to read these informative articles.

Finally, the editors are happy to receive feedback on how to deliver a better service to the authors, readers, and subscribers that will result in the overall improvement of the journal.

Abimbola Windapo *PhD*
Editor-in-chief

ABOUT JCBM

The **Journal of Construction Business and Management (JCBM)** is an open access journal published bi-annually by the University of Cape Town Libraries, South Africa. The Journal is hosted by the Construction Business and Management Research Group of the University of Cape Town. The journal aims to explore the experience of construction industry stakeholders and trends in the global system. It aims to publish peer reviewed and highly quality papers emanating from original theoretical based research, rigorous review of literature, conceptual papers and development of theories, case studies and practical notes. The journal also welcomes papers with diverse methodological research approaches including qualitative, quantitative and mixed methods. Contributions are expected from academia, public administrators, professionals in the public sector and private practice (such as contracting organizations and consulting firms) and other related bodies and institutions (such as financial, legal and NGOs).

The scope of **Journal of Construction Business and Management (JCBM)** covers, but is not limited to construction management and project delivery, strategic management, decision making, skills development, organizational practices and procedures in construction business. The specific areas in construction management, sustainability in construction and project delivery include project planning/feasibility studies, procurement, resource management, international construction, ethical issues, industrial relations, legislative requirements and regulations, construction education, information and communication technologies, housing policies, and urban design and development. Strategic management in construction covers risk management, quality management, resilience and disaster management, cultural and societal management, project life cycle management, and knowledge creation and management. Among issues in construction organizational practices and procedures covered are business development strategies, human resources and career development, continuous professional development, leadership systems, marketing strategies, gender issues and corporate social responsibility.

Journal of Construction Business and Management (JCBM) is a peer reviewed journal. All research articles in this journal undergo rigorous peer review, based on initial editor and anonymised refereeing by at least two anonymous referees.

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A Qualitative Study of Health and Safety (H&S) Construction Practices in Lagos

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Abstract

Projects in the construction sector are reputed for poor H&S records when compared to other similar industries. This can be attributed among other things to an uncontrolled working environment, risk, workers' behaviour in relation to H&S commitment, cultural and religious beliefs, and uncertainties inherent in projects. Risk and hazards arising due to poor H&S practices result in injuries and fatalities in few cases. The aim of this study is to explore the perceptions of workers regarding H&S on construction sites. A combination of interviews and observations was conducted in the study. The participants in the study are mainly production workers (ironworkers, masons, carpenters, roofers, and electricians) engaged in construction projects. The findings of the study reveal that workers view productive activities on construction sites as hazardous and risky. However, lack of understanding the use of PPE affects its use. This perception may also be attributed to inadequate training, socio-economic realities, cultural and religious beliefs. Therefore, there is a need for a localised H&S certification and awareness programmes to foster a commitment to improving H&S at construction sites. Further research is required to understand the influence of stakeholders on H&S practices in the Nigerian construction industry.

Keywords: Health and Safety; Nigeria; Perceptions; Workers.

1. Introduction

The construction sector is viewed as an accident-prone industry. Studies on H&S in the field of construction management reiterate the poor H&S performance on construction sites as a global phenomenon (Zhou *et al*., 2013). It has been established that poor H&S practices among workers significantly contributes to the poor H&S performance reported in construction-related studies (Haslam *et al*., 2005; Choudhry and Fang, 2008). Also, complexities experienced in the industry due to changing technology, construction methods, clients' demands, construction materials and the changing environment have made hazards and risk controls difficult (Odeyinka *et al*., 2006). It is evident that some factors are principally responsible for poor H&S performance at construction sites. However, it is evident that workers' practices are within the control of the contractor whom may not be able to influence the other identified factors. Hence, improving workers, H&S practices could result in reduced accidents at construction sites.

The statistics emerging from the construction industry highlights the need for a paradigm shift in the H&S performance of projects. According to the International Labour Organisation (ILO, 2005), an estimated 2.3 million people die every year from work-related accidents and diseases, and there are 313 million non-fatal accidents per year. Furthermore, 30% of workers suffer from musculoskeletal disorders and more than 20%-40% of work-related deaths occur on construction sites in industrialised countries. It was reported that 31% of all occupational-related deaths in 2002/03 occurred in the construction industry (Haslam *et al.*, 2005). Chi and Han (2013) also state that on every work day, more than three workers do not return home due to fatalities experienced on construction sites in the United States of America (USA). Similarly, the construction industry development board in 2008 records that South Africa had fatalities and accident rates of 19.2 and 14 626 per 100,000 workers respectively. This is said to be lower than that of sub-Saharan countries estimated at 21 and 16 021 per 100 000 workers respectively (CIDB, 2008). Cokeham and

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Tutesigensi (2013) note the high accident rate in Rwanda and the increase in other sub-Saharan countries. Hence, the statistics suggest that poor H&S performance is a global problem.

Poor H&S record can give rise to poor project performance which is commonly observed in the construction sector. It has been reported that accidents lead to increase in operation cost of projects (Hinze, 1997; Willkins, 2011). These could be due to poor productivity, the cost of medical care for victims, loss of person hours, absenteeism, and an adverse impact on the image of the organisation. The need to improve H&S at construction sites has been a subject of several years of research (Koehn *et al.,* 1995). It should be noted that it has been reiterated that high rates of injuries and death of workers can be linked to workers' non-compliance with H&S procedures, inadequate training, and insufficient knowledge of H&S practices (Willkins, 2011). Thus, this necessitates the need for a study to understand how workers view H&S in the construction environment.

As highlighted in the opening paragraph, arguments and evidence indicate that the construction industry has a poor H&S record. Despite the fact that Nigeria is a member of the ILO, H&S provisions and conventions are not properly implemented (Umeokafor *et al.*, 2014). In a similar vein, Idoro (2008) asserts that there are no policies prescribed for H&S in the Nigerian construction industry. Therefore, contractors and employees are left to use their discretion. As suggested by Khosravi *et al*. (2014), construction workers executing the task in an unhealthy and unsafe environment could give rise to poor productivity. Furthermore, it is known that research provides a body of knowledge that guides a discipline. A review of past published and unpublished studies in construction management-related disciplines in Nigeria and the West-African region reveal that H&S related research has been limited (Laryea & Leiringer, 2012; Ejohwomu and Oshodi, 2014), except for few studies (such as Windapo and Jegede, 2013). Hence, construction workers executing the task in unhealthy and unsafe environment could give rise to poor productivity. The reported study assessed the perception of workers' on H&S in the Nigerian construction industry using a qualitative approach. The present study offers some valuable insights into the H&S issues on construction sites in Nigeria.

2. Improving H&S Performance in the Construction Industry

Implementing H&S 'best' practices on construction sites can be challenging. There are several possible explanations for these challenges; such as migration of workers, method of worker employment, work standards, different backgrounds and experience (Mohamed *et al*., 2009). Also, adoption of 'best' H&S practices attracts little attention from the construction sector. This is because stakeholders are largely profit-driven and give H&S little considerations (Priyadarshani *et al*., 2013; Windapo, 2013). To address poor H&S performance in methods is that it provides deep insights into the study's problem (Levy & Henry, 2001; Creswell, 2012). Literature shows that there is a general preference for the construction industry, it is important to understand its meaning.

Research into H&S in construction-related disciplines has a long history. Agumba, Pretorius & Haupt (2013) define H&S management as "tangible practices, responsibilities, and performance related to H&S, including the association between H&S management, climate, and culture." Smallwood (1995) maintains that management commitment to H&S is reflected in the organisation's values, policy, goals, programme development, resource allocation, behaviour modelling, and injury analysis. However, H&S management techniques should be tailored to meet the unique needs of the worker. Agumba, Pretorius & Haupt (2013) further categorise H&S practices into five basic elements, namely top management commitment and involvement in H&S, employee involvement and empowerment in H&S, project supervision, project H&S planning, communication in H&S and H&S resources, and training. The study reveals the importance of employee involvement and empowerment in H&S on a construction site. It was recommended that workers should be engaged at the project level to improve H&S performance on construction sites. Researchers such as Cheng *et al*. (2004), Cheng *et al*. (2012), and Ismail *et al*. (2012) opine that limiting human errors will reduce accidents, which can only be achieved by employing H&S management best practices on site. When the system is driven positively to reduce hazards and risks, workers will adopt good behaviours to foster positive commitment to H&S. Thus, understanding how workers perceive H&S may lead to valuable insights that can be determined to improve on-site construction H&S.

Windapo and Jegede (2013) are of the opinion that fatalities, injuries, and deaths are mainly caused by unsafe and unhealthy practices of contractors and workers. Contractors prefer to spend less on PPE, employ less experienced workers for cheap labour and care only for the profits to be made. Similarly, from a qualitative survey, Khosravi *et al*. (2014) identified eight main categories of factors that influence workers' unsafe and unhealthy behaviours on construction sites. These factors include society, organisation, project management, supervision, contractor, site conditions, work group, and individual characteristics. Workers' perceptions of risk, H&S management, H&S regulations, and procedures have been linked to their attitude towards H&S on construction sites (Mohamed *et al*., 2009). The study mentioned above reveals that workers have a self-rated competence and their behaviour relates to their H&S responsibilities.

3. Research Methodology

The investigation reported here is part of an on-going study targeted at understanding and suggesting improvements to construction workers' H&S practices in Lagos, Nigeria. Interview and participant observation are the data collection methods adopted in this study. A significant advantage of the qualitative data collection quantitative research method in construction management studies focused on Nigeria (see Ejohwomu and Oshodi, 2014). Hence, the use of qualitative method in this study gives an alternative perspective towards the H&S problems at construction sites. The primary sources for the semi-interview questions included a literature review on H&S (Gillen et al., 2004). The questions enabled the workers to discuss the following topics: H&S training, risk awareness, use of PPE, and employee and management interactions as regards H&S; and probes for some of the questions were also developed.

The data provides actual words of the respondents. The findings of Baradan and Usmen (2006) determine that roofers, iron workers, electricians, painters, and masons were more at H&S risk and ranked highest in fatalities when compared to other work trades in the construction industry. Based on this finding, a worker from each of the trades was selected and interviewed. The small size of respondents (interviewees) was to allow for an in-depth discussion and for the workers to adequately express their ideas without restrictions. The questions were structured to allow the respondents to discuss their general impression of H&S on site, work environment, and how work is conducted in a healthy and safe manner. Observations were carried out during project activities as interviewees granted access to site.

All ethical issues were addressed such as formally requesting to visit and interview the respondents, explaining the purpose of the research, and asking for the workers' consent based on a voluntary decision to be interviewed. The contracting firms selected for this study are registered with the Nigerian Institute of Building (NIOB). There are 191 construction companies registered with the NIOB. Ninety-two (92) of these firms are based in Lagos. The selected companies were those undertaking projects at the time of the research. Further questions were asked to prompt discussions in relevant areas during the interview. The interviews were recorded (with permission of interviewees) and were conducted in both English and local languages. The transcripts of the study were translated into English (for those interviews carried out in local languages) and then transcribed. The interview sessions were conducted during the lunch breaks and after-work hours. This was because two of the workers surveyed, preferred to be interviewed after work. Their ages, educational status, and years of experience were noted.

3.1 Participants of the study

3.1.1 Interviewees' characteristics

The respondents (Table 1) were all male adults between the ages of 30-49, and they all had more than eight years' work experience, which indicates adequate work experience to provide responses that reflect actual practices on construction sites. The interviewees have been engaged in several projects ranging from engineering works (dam, road, and bridge construction) and building structures (residential and commercial buildings). This reveals that the interviewees' had varied work experiences on different construction sites. This will enhance the quality of the responses on H&S. Of the five respondents, only one had a trade school certificate. The other four were primary and secondary school leavers; they all learned their trade through informal training, i.e. working as an apprentice until they were set to work on their own.

Table 1: Characteristics of the interviewees

Interview code	Trade	Gender	Age	Highest qualification	Years of experience
R1	Roofer	Male	Adult	Primary education	10
R2	Ironworker	Male	Adult	Secondary education	16
R3	Electrician	Male	Adult	Trade school certificate	13
R4	Painter	Male	Adult	Secondary education	9
R5	Mason	Male	Adult	Primary education	9

4. Findings and Discussion

This study explored the perception of workers regarding H&S practices on construction site. Thematic analysis of interview was used to analyse the qualitative data. First, the qualitative research result will be presented followed by the observations. We asked the interviewees to reflect on the training received, use of PPE, hazards, and risks. Three broad themes emerged from the analysis: H&S training, perception of risk, and management commitment/workers' involvement to H&S. Other H&S issues were raised during the discussion. The issues were categorised as workers union and clients commitment to H&S.

4.1 H&S training

Interviewees indicated that H&S training is not conducted on construction sites as suggested by R5*: "There is nothing like H&S meetings or training since I started working with this contractor"* and R4*: "I do not know anything about H&S training."* They have not attended any H&S training. Therefore, the workers regarded H&S training as unnecessary to their work. They are of the opinion that, H&S officers are not available on site, H&S meetings were not conducted, and communication was through the supervisors and foremen. R1*: "The management does not involve us in any meeting so that we can talk; they mostly talk with our foremen. The foremen will now pass the information down to us."*

As regards to the use of PPE, the interviewees indicated that they were familiar with some PPE such as goggles, ear plugs, hand gloves, helmet (hard hat), boots, reflective jackets, and overalls. However, the use of PPE was not regarded as important or necessary. Interviewees expressed their opinions R3*: "Some of the PPE were not durable; they were of low quality and these contractors buy them to reduce cost,"* and R2: *"They give me hard helmet and boots, only a pair."* This indicates that management does not commit adequate resources to H&S and do not care about the H&S of their workers. Also, workers do not understand the need to wear H&S equipment due to various reasons as indicated by some of the interviewees; R4*: "PPE in this hot weather! The weather is too hot to wear them; it makes me very uncomfortable, I will be sweating."* R5*: "It is only when the client and other professionals are coming to site for inspection that my manager will bring them out and insist we wear helmets, boots, and overalls."* R1: *"The helmet and overall are not necessary. I like using the hand gloves. I do not think I really need it for my job."* However, others indicated that some managers they have worked with insisted they use PPE as reported by R3*: "I have worked on sites where the managers will insist we use our PPE."*

4.2 Workers' perceptions of risks

The workers were further asked if they were aware of the degree of risk and hazards related to their work and how accidents are reported on site. Some of the workers affirmed that working on construction sites involves risk. However, they have worked long enough on the job to avoid accidents; they know the "tricks on the job." Interviewee R1 views risk in this way: *"Every job has a risk if no risk then no money. It is not easy to climb on a roof and work; the higher it is, the more the money. I have been doing this job, and I am still alive; I think when you are afraid that is when you fall."* They believed they are safe. Others believed they are at risk only when their supervisors or managers insist on a construction method which they are not familiar with, and they try not to get afraid. R5: *"My boss tells me to do some work, and I do the work the best way I can. I feel safe. I am a man I cannot be afraid of my work. I like my work".* R2 and R4 have similar views*: "For me, when something wants to happen it does happen, and you cannot stop it. It is just God or our forefathers that are keeping us safe because we have to provide for our families." We just have to do the job"; "I just pray to God to help me do my work well and not to get injured."* Accidents, according to one of the interviewees*: "Happen every day, you just have to be careful. Sometimes you may be lucky, and other days you are not, and if you get injured often you may not be employed again"* and that *"Reporting accidents depends on the seriousness of the accident. Managers handle serious cases, and accidents are investigated with help from the foremen or supervisors. When an accident leads to death, the families are compensated, but I do not know if the police are involved."*

4.3 Management commitment to H&S / employee involvement in H&S

Although the interviewees did not attest to any onsite H&S policies, regulation or rules, respondents perceived that some managers were committed to their wellbeing while others were not. According to R3*, "Most of the sites I have worked, have different types of managers and with different work behaviour. Some will make your work easy because they want good work done"* and *"others will make you work and work making you accomplish some impossible workload as a day's job because they want to save money."* Management commitment to the workers' wellbeing was perceived by the interviewees as not sufficient. They are of the opinion that H&S is not relevant on most sites according to R2: *"Where I worked, they don't say anything about H&S."* However, R3 is of the opinion that *"We were taught how to keep our environment clean after work so that your work will be neat and also the site."* Getting involved with H&S on site depends on the management. However, due to workers' level of education, most workers prefer not to get involved with Management R1*: "we are not as educated as they are so we just work."* The workers prefer to do their work and get paid their wage. Furthermore, management does not show empathy and respect for the workers as indicated by an interviewee. R1 is of the opinion that management is more concerned about work rather than their H&S practice*; R5: "But some managers do not see us workers as human beings. I am saying this because the man* (i.e. the contractor's representative) *was more concerned about the work being done right rather than about us."* R3*: "Managers, engineers, and supervisors talk to us with disrespect. This often occurs especially when the work is delayed."*

All the interviewees gave accounts revealing that the management of contracting firms was not committed to implementing H&S during the construction phase. Responses from interviewees above identified managers who expected workers to carry out tasks that cannot be accomplished within the time frame allotted to the task. Their concern as stated above implies management's poor H&S commitment on construction sites. Hence, workers' do not view H&S as a priority on project sites.

4.4 Other concerns:

A standard view mentioned among interviewees are categorised below:

4.4.1 Workers' trade union

Interviewee R2 and R5 are members of Trade Unions. This gives them welfare benefits. They can easily access loans and receive help in the case of any labour dispute. However, their responses were similar stating that contractors do not allow active participation in union activities in their organisations. This implies that the union has an influence on the members. This was made clear by the following statements: "I am a union member because when I need help, they will help me. We make monthly contributions as members, and we get information about work easily." "I was a union member when I was in permanent employment with a big company as a union member; we fight for our wage increase or when they don't treat us well." "When I get employed for work on any site, I do not tell them I am a union member *because you may not get the job; they say as union members we fight always."*

4.4.2. Clients' commitment to H&S

The interviewee raised a point relating to stakeholders on site and H&S. The interviewee reported that *"when we work in big projects our supervisor talks with us and gives us things like boots, and helmet, but for small projects, it is rarely provided." "I have worked where the bosses (*professionals and the clients*) visit the site to see the work and have meetings; the sites are always big projects." "In this kind of work we use PPE and work well."* Interviewees further agreed that in such large projects, the clients' visit the sites for inspections and emphasis are laid on H&S practices such as cleanliness, proper scaffold use, smoke-free on construction site and use of PPE.

From the analysis of qualitative data, it is evident that clients have an influence on H&S practice and the magnitude of projects may also be an influence on H&S on construction sites. Hence, large construction firms may have better policies towards H&S practices than small companies. This assertion is similar to that of Farooqui et al. (2008).

Lack of management commitment to H&S, the lack of respect towards workers, and H&S influence of clients (stakeholders) have a negative effect in the Nigerian construction industry. These have affected the effective management of H&S within the Nigerian construction industry. Hence, the poor H&S practices on construction sites. Also, stakeholders are not involved in H&S which may be a major contributing factor to inadequate policy formation and implementation especially with respect to H&S practice in the construction industry in developing countries.

4.5. Observations on workers' H&S practice during site activities

Everyday on-site activities are recognised as vital contributors to on-site H&S practices. Examples include provision of welfare facilities such as first aid, restrooms, baths, changing rooms, and food canteens; general housekeeping; material handling; plant and equipment handling; and use of PPEs by workers.

Figure 1: Workers at work on construction site
(Kukoyi and Smallwood, 2016)

Figure 2: Workers at work on construction site
(Kukoyi and Smallwood, 2016)

Figure 3: Workers at work on construction site
(Kukoyi and Smallwood, 2016)

Figure 4: Workers at work on construction site
(Kukoyi and Smallwood, 2016)

The pictures (see Figure 1 to 4) above are representations of observations conducted during site activities. The pictures show the state of H&S practice on the construction sites visited. Some issues were identified; Figures 1 and 2 indicates the poor use of PPE, none of the workers were adequately dressed for the activity. Plant, equipment, and materials were not properly handled. Figures 3 and 4 shows the inappropriate use of scaffolds, poor housekeeping, and inadequate material handling on site. Poor practices of the workers during construction operations suggest the level of management H&S, level of H&S awareness and H&S perception of workers. However, restrooms, changing rooms, and food canteens were provided for the workers.

The findings of this study reveal that workers are aware of the risks and hazards associated with work. This is different from the findings of Ulubeyli *et al.* (2014) which suggest that workers are not aware of the risks or hazards on construction sites. However, this study suggests that the workers were more interested in monetary gains than concern for the risks they were exposed to, and relate accidents to lack of precautionary methods when at work. This is probably confirmed with the workers' poor use of PPE during construction activities as shown in the results. However, this may be attributable to the low socio-economic characteristics of the workers, and unfair labour practices. Furthermore, risks and hazards, associated with the workers' trades on construction sites, are also viewed within the context of workers' religious beliefs. This result is in agreement with Smallwood's (2002) findings, which demonstrate the link between H&S and religion. Also, the activities of workers' unions are limited on construction sites. The unions are not adequately represented on construction sites in Nigeria. Furthermore, if trade unions are fully established, this could serve as a platform to promote H&S on construction sites and engender stakeholders' commitment and workers' involvement in H&S. This is buttressed by the findings of various studies regarding how unions and union workers have contributed to improving H&S on construction sites in various countries (see Debobeeleer, 1990: Ulubeyli *et al.*, 2014).

Lastly, the results of the study also raised related questions regarding the available H&S training for workers on construction sites. Workers lack formal H&S training; an indication that H&S is not a priority to stakeholders and the workers. Hence, poor H&S practices on construction site. The need for adequate codes of conduct, policy formulation, and implementation in the construction industry in Nigeria is vital.

5 Conclusions and Further Research

The work environment in the construction industry is unsafe. This suggests the need to adopt H&S practices so as to improve H&S performance of construction projects. This paper explored the perceptions of workers on H&S practices on construction sites. The study adopted a qualitative research approach. This method enabled an understanding of the H&S perception of workers in the Nigerian construction industry.

The findings of the study reveal that workers view construction activities as hazardous to them, and are more interested in the monetary gains. They have little or no knowledge of what H&S in construction is about due to a lack of H&S training. Workers view that the number of years spent in a trade determines the level of risk they are being exposed to, and how to manage it. Also, religion is a determining factor of how risk is perceived and managed. Therefore, the workers expose themselves to avoidable risks. In summary, their perceptions could be linked to stakeholders' inadequacies in promoting H&S practices, socio-economic realities, cultural beliefs, and inadequate training.

This research has established the importance and the need to train workers in the Nigerian construction industry. The government and other stakeholders should develop strategies and policies that will foster commitment to H&S on construction sites. Given the sample for the present study, is not a representative of the total number of workforce, it should be seen as a limitation to the study, and therefore cannot be generalised. However, the findings provide insight to stakeholders in the industry as regards H&S. Further research is needed to understand the H&S influence stakeholders have in promoting H&S and training needs of workers in the Nigerian construction industry. Construction Managers could plan H&S strategies with supervisors to systematically analyse work risks and hazards. This will enable management to improve the H&S climate on projects and to develop an H&S culture among workers through adequate policy formulation and implementation.

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Determinants of Building Construction Costs in South Africa

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Abstract

Completing project within cost is the target of most clients on any construction project. However, the achievement of this desire is just an imagination in the construction industry, because procurement and execution environments for projects are hostile and unpredictable. This study examines the determinants of building construction costs in South Africa and whether changes in the cost of certain resource factors such as construction equipment, labour and materials can be related to changes in building construction costs. The study employs a longitudinal cross-sectional quantitative research design approach and makes use of literature review and historical data obtained from institutional and governmental databases to identify the determinants. The data collected were analysed using time series analysis to confirm the trends in the cost of the resource factors and its alignment to the changes in building construction cost. After that, it makes use of an appropriate predictive modelling tool or causal analysis in establishing the determinants of construction cost. The results show that the price indices of construction equipment (EI), labour (LI) and materials (MI) have a gentler slope when compared with the Building Cost Index (BCI). It also emerged that later levels of the BCI are significantly and positively related to EI. The findings infer that the key determinant of increase in building construction costs in South Africa is equipment costs. Contractors and public or private sector clients in South Africa must utilize construction equipment optimally on projects, and these pieces of equipment should not be left idle on project sites or plant yards. Appropriate provisions should be made of equipment utilization policies which allow the joint ownership of equipment by contractors to mitigate the problems of cost increases. There are widely unexamined assumptions as to what resource factors are responsible for the growth in building construction costs in South Africa. Also is the similar high risk and uncertainty affecting the South African construction industry as a result of these fluctuations. The results of the study extend the knowledge of the resource factors responsible for building construction costs increases.

Keywords: Construction Equipment; Cost Data; Labour; Materials; South Africa.

1. Introduction

It is the desire of every client to achieve value for money on any construction project. This desire is often not met on most projects because of the unforeseen events and unpredictable factors influencing costs of projects at the planning and development stages. This study, therefore, examines factors that determine the cost of a construction project in South Africa. It also investigates whether the change in the cost of construction resources influences the trends in building costs. The outcome of this study informs contractors and public and private clients of the likely level of increases in the cost of construction work, to predict future changes in the costs of construction projects. Hence, the paper presents in Section 1 an introduction, outline, and rationale of the study to readers. Section 2 describes a critical review of the literature on the drivers of construction cost. Chapter 3 discusses the method employed in collecting the data reported in the paper, while Section 4 outlines the findings emanating from the data analyzed and the results were related to the existing knowledge on drivers of construction costs. Section 5 presents the conclusions drawn from the results and highlights future research.

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2. Identification and Review of Construction Cost Drivers

Construction costs are the portion of hard costs usually associated with the construction contract, including the cost of materials, the labour and equipment costs necessary to put those elements in place. Overhead costs, which include both job site management and the contractors' standard cost of doing business are added to this.

Theoretical underpinning and constructs of the notable drivers of cost of construction work proposed in this research are aligned to the findings of previous studies by Odediran and Windapo (2014); American Institute of Architects (2013); Olatunji (2010); Skitmore et al. (2006); Lowe et al. (2006); Sawhney et al. (2004), Ng et al. (2000); Akintoye et al. (1998); Fitzgerald and Akintoye (1995); Chau (1990); Eastman (1986); and Snyman (n.d). Based on literature review (see Tables 1 and 2), the drivers of construction costs are classified into – Resource factors (labour, material and plant); Project factors (competition intensity, profit margin, overhead cost, space available for construction, management skills provided, type of structure/design and construction methods used); Macroeconomic factors (demand and supply of construction work, finance or loan cost, inflation, transportation costs, energy costs, exchange rates and fuel price); construction work items (excavation, concrete work, formwork, reinforcement work, mechanical, electrical and plumbing installation etc.); and stakeholder requirements (professional fees and transaction costs).

Table 1: Resources Factors Based on Previous Studies

Resource Factors	**Relevant studies**					**No. Cited**
	Odediran & Windapo (2014)	Skitmore et al. (2006)	Sawhney et al. (2004)	Eastham (1986)	Snyman (n.d.)	
Labour	✓	✓	✓	✓	✓	5
Materials	✓	✓	✓	✓		4
Equipment/Plant	✓	✓	✓	✓		4
Sub-contractors				✓		1

Table 2: Project Factors Based on Previous Studies

Project Factors	**Relevant studies**						**No. Cited**
	Skitmore et al. (2006)	Sawhney et al. (2004)	Akintoye (2000)	Fitzgerald & Akintoye (1995)	Eastham (1986)	Snyman (n.d.)	
Contracting practices		✓	✓				2
Location			✓		✓		2
Size of project			✓		✓		2
Contract/project duration			✓		✓		2
Tender period			✓		✓		2
Quality of market information			✓	✓			2
Bargaining Power of Unions			✓	✓			2
Variations in materials		✓					1
Labour Productivity		✓					1
Equipment Usage		✓					1
Weather		✓					1
Soil conditions		✓					1
Quality standards expected		✓					1
Anticipated use		✓					1
Overhead cost	✓						1
Degree of competition					✓		1
Method of construction			✓				1
Site constraints			✓				1

The focus of this study will be of the contribution of resource factors to the cost of construction. Resource elements are the inputs used in the production process to produce an output – the final building or infrastructure product in development. According to Odediran and Windapo (2014); Skitmore et al. (2006); Sawhney et al. (2004); Eastham (1986); and Snyman (n.d), resource factors contributing to the cost of construction work in no particular order, are cost of construction equipment, labour, building materials and specialist sub-contractors. Building materials and materials will be used interchangeably in this paper.

3. Research Methodology

There are significant numbers of earlier studies either on cost forecasting or prediction in South Africa (Bowen, 1993; Snyman, 1989a; Snyman, 1989b; Bowen and Edwards, 1985; and Bowen, 1980). Historical cost data are mostly used for the purpose of predicting the future levels of construction costs as they provide trends in prices and reliable information than macroeconomic variables (Smith, 1995; Tysoe, 1981). This study examines resource factors – construction equipment, labour and building materials that are established in the literature. The study determines the relationship between the cost of these resource factors and construction costs and adopts a longitudinal cross-sectional survey research design in data collection.

A desk-top study that employs data collection methods involving data mining in achieving the research aim. The determinants of construction costs were established using historical information obtained from institutional and government databases (Stats SA, Bureau of Economic Research (BER)/Medium-Term Forecasting Associates (MFA) archives. The data/indices obtained were after that analyzed using descriptive tools to confirm the trends in the construction cost and after that, a predictive modelling tool or causal analysis to establish the determinants of building construction costs. Ashuri and Lu (2010) noted that the causal methods assume that the independent explanatory variables determine the variables to be predicted in the form of regression models. Ruddock (2008) acknowledged that regression and correlation are usually considered together in expressing a relationship between two variables. Simple or linear regression finds straight-line hypothesized relationships only, and mathematically represents this as equation (1):

$$y = a + bx \quad (1)$$

Where
b = slope of the line of best fit (estimate/regression line)
x = values of the independent variable (that is resource factors in this study)
y = values of the (hypothesized) dependent variable (that is BCI in this study)
a = y-intercept/constant

The Building Cost Index (BCI), which is a measure of the trends in the estimate of the cost required to complete a construction project, were used in the study as a measure of the growth in building construction cost. While the indexes of the resource factors – labour, material, and equipment, were used as a measure of the cost of the resource factors. The Labour Cost Index (LI) is a measure of the trends in the all-in-rate (payroll taxes and profits) of the skilled workers obtained from Department of Trade and Industry (Dti) records. The Building Material Price Index (MI) is a measure of the trend in changes in the prices of volatile construction materials. The indicator of building materials price trends used in this study is obtained from the published Building Materials Production Price Index available in the Stats SA archive. Also, the Plant Cost Index (EI) is used to measure the change in plant costs on a quarterly basis, is made up of construction equipment/plant hire rental (Stats SA, 2010).

According to Dysert (2008), regression modelling is a mathematical representation of cost relationships that provide a logical and predictable correlation between the physical or functional characteristics of a project (plant and process system) and its resultant cost. The process of regression modelling, therefore, lends itself towards the course of finding the significance between independent variables that have direct effects on a dependent variable, a contextual environment, which is typified by the construction process. Advantages of regression modelling for estimating purposes is the provision of efficiency regarding developing estimates in a shorter period. Linking quantitative inputs to algorithms to provide quantitative outputs, often allows two estimators to come to the same conclusion regarding cost, and it is flexible as it allows a range of independent input variables that have been derived from historical data (Black, 1984).

4. Findings and Discussion

Historical data collected from BER/MFA data and analyzed is presented and discussed in the following sub-sections.

4.1 Trends in Historical Cost Data for Construction Costs and Resource Factors

The study sought to know descriptively, the trends in the historical cost data for construction costs and the resource factors (construction equipment, labour, and building materials) in South Africa. The results of this inquiry are presented in Figures 1 and Table 3.

Table 3. Distribution of Building Cost, Labour, Material and Equipment Indices by Year (2010-2015)

Date	Building Cost Index (BCI)	Normalized Labour Index (LI)	Normalized Material Index (MI)	Normalized Equipment Index (EI)
2010Q1	145,7	174,5	216,5	188,3
2010Q2	144,8	176,4	218,3	187,9
2010Q3	142,0	177,8	218,9	186,7
2010Q4	142,4	178,6	219,9	186,7
2011Q1	140,8	181,2	223,3	186,0
2011Q2	149,2	184,5	225,5	187,9
2011Q3	147,8	187,4	228,3	189,2
2011Q4	156,7	189,4	230,5	187,9
2012Q1	153,3	191,8	233,1	185,9

2012Q2	156,1	193,2	234,5	186,5
2012Q3	161,4	194,1	235,5	187,4
2012Q4	164,9	194,3	236,7	188,2
2013Q1	171,0	197,3	239,5	189,8
2013Q2	165,7	198,7	240,8	191,5
2013Q3	173,3	200,3	242,9	194,9
2013Q4	171,8	201,1	244,9	196,8
2014Q1	179,2	203,3	247,1	198,7
2014Q2	186,6	205,3	249,0	200,3
2014Q3	191,2	206,8	249,9	200,8
2014Q4	194,3	207,0	250,7	200,6
2015Q1	198,2	207,7	250,5	202,2
2015Q2	186,3	210,4	250,5	202,8
2015Q3	196,2	212,0	250,9	203,6
2015Q4	197,0	212,4	247,3	208,2

Source: BER/MFA Data (2016)

Table 1 and Figure 1 compares the trends in Building Cost Index (BCI), Construction Equipment Index (EI), Labour Index (LI) and Material Index (MI). The result shows that the indices of equipment, labour, material have a gentler slope when compared with BCI. MI has a wider differential when compared to BCI. While the EI and LI have smaller differentials when compared to BCI, the growth rate of MI and LI are proportional except for the growth rate of EI which is not uniform over the years. There was an overlap in the growth rate of LI and EI in the year 2011 and 2012, meaning that the indices are to some extent unrelated. Moreover, the BCI, LI, and EI grew proportionally showing that they have the same growth rates.

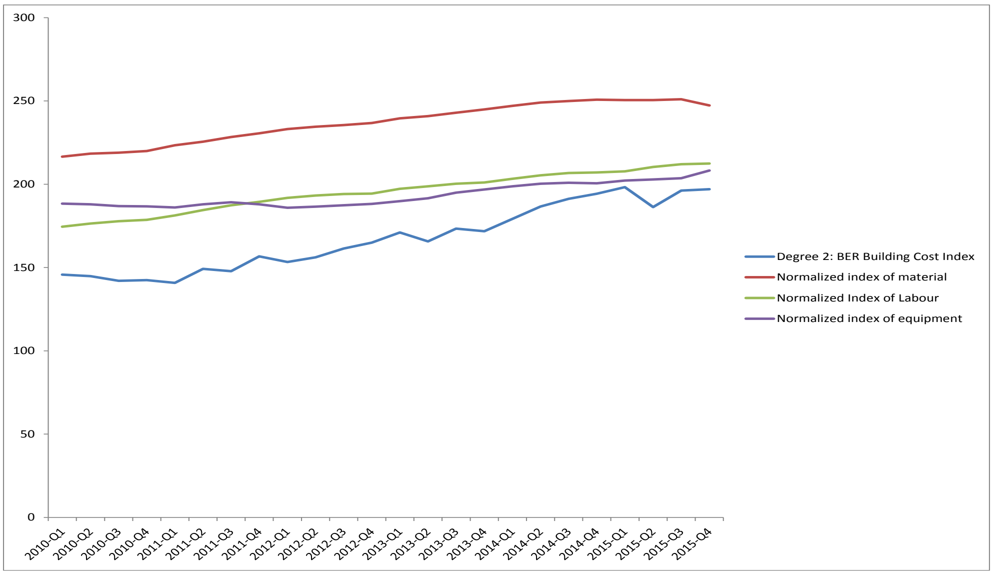

Figure 1: Comparing the Trends in Material, Labour, Equipment Indices and the BCI

4.2 Multiple Regression between BCI, LI, MI and EI

Further investigation was undertaken to find out whether there is any significant relationship between BCI (dependent variable) and LI, MI and EI (independent variables) using multiple regression analysis. Table 4 shows the results of the multiple regression analysis at 95% confidence level between BCI, LI, MI and EI4. Table 4 demonstrates that:

- The correlation between Building Cost Index (dependent variable) and Labour Index, Materials Index and Equipment Index (independent variable) is very high (0.961556313) means 96% correlation – the combined changes in labour, materials, and equipment indices explains 96% of the changes in BCI;
- Significance Value of Error is minuscule (2.56297E-14) meaning that the error is not significant; and
- At 95% confidence level the P value of the intercept is 1.85276E-07<0.05, Labour Cost is 0.855670171>0.05, Materials Cost is 0.08363076>0.05 and Equipment Cost is 0.000101165<0.05. The P values of the intercepts mean that the constant values of the intercept and Equipment cost are significant, but Labour cost and Materials Cost are not significant.

• The relationship between BCI and the resource factors can be modeled as BCI = -298,06 + 1,25*EI.

Table 4. Multiple Regression between Building Cost Index, Labour Index, Material Index and Equipment Index (95%)

Regression Statistics	
Multiple R	0,98
R Square	0,96
Adjusted R Square	0,96
Standard Error	4,17
Observations	24

ANOVA	*df*	*SS*	*MS*	*F*	*Significance F*
Regression	3	8689,86	2896,62	166,75	2,56297E-14
Residual	20	347,43	17,37		
Total	23	9037,29			

	Coefficients	**Standard Error**	**t-Stat**	**P-value**	**Lower 95%**	**Upper 95%**	**Lower 95.0%**	**Upper 95.0%**
Intercept	-298,06	38,40	-7,76	1,85276E-07	-378,17	-217,96	-378,17	-217,96
Labour	0,10	0,52	0,18	0,855670171	-0,99	1,18	-0,99	1,18
Material	0,87	0,48	1,82	0,083630760	-0,13	1,86	-0,13	1,86
Equipment	1,25	0,26	4,83	0,000101165	0,71	1,78	0,71	1,78

Based on these findings, it can be inferred that a unit increase in the price of equipment will lead to 25% increase in the cost of building construction. However, there was no significant relationship between building construction cost and the cost of materials and labour.

5 Conclusions and Further Research

The primary objective of any pricing regime should be to ensure that there is an efficient allocation of resources and an understanding of the indicators and drivers that will aid decision making, in managing cost related to the construction sector. This study examines the determinants of building construction costs in South Africa and whether changes in the cost of certain resource factors such as construction equipment, labour and materials can be related to changes in building construction costs. Overall, the research observed that although there is a gradual increase in construction cost, this is not increasing proportionally with inflation and that there is a significant positive relationship between construction costs and equipment costs when historical cost data are analyzed. It also emerged that a unit increase in the price of construction equipment will yield 25% increase in building construction cost. Based on these findings, it can the study concludes that equipment use is a major determinant of building construction costs in South Africa and that increases in equipment costs will yield proportionally significant increases in construction costs.

Based on these findings, the study recommends that contractors and public or private sector clients in South Africa must utilize construction equipment optimally on projects, and these pieces of equipment should not be left idle on project sites or plant yards. Appropriate provisions and policies should be made to allow the joint ownership of equipment by contractors to mitigate the problems of cost increases. The study also proposes that further research is undertaken using actual construction projects in validating the results obtained in this study.

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Groins or Not: Some environmental challenges to urban development on a Lagos coastal barrier island of Lekki Peninsula

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Abstract

Worldwide, barrier islands are usually sedimentary, dynamic and in high demand for urban development. Intense development negates their dynamics leading to risks necessitating protective measures like groins which tend to aggravate the problem. Suburban Lekki Peninsula on the south of Lagos metropolis is a large, long barrier island disposed largely to unplanned, accelerated growth since the first residential scheme in 1980 without consideration of its physical dynamics. This study, therefore, evaluated some risks confronting development from the dynamics of the Peninsula with the goal of demonstrating the use of low - budget online data for analysis of coastal hazards and risks. This entails the integration of remote sensing, GIS techniques to assess its characteristics and evaluate risks to development from some hazards inherent in island's physical processes as a typical barrier island on the Lagos coastline. Findings reveal that the area which was hardly built up in 1984 had grown to about 18% in 2014 with Eti-Osa LGA as the most developed at 68.4% and the most low-lying of the three comprising councils. Results further confirm the Peninsula as narrow in a few sections and generally low-lying with 37% between 0.5 - 3m while 63% is between 3 - 5m above mean sea level (MSL). Medium to maximum rates of beach erosion occur mainly in Eti-Osa LGA at about 22.75m/yr around Kuramo Waters, decreasing to 5.5m/yr around Goshen Estate. Projections on coastal erosion on the most erosive area in Eti-Osa LGA from 2013 reveal potential socio-economic impacts on road infrastructure and buildings as ranging from a minimum of N1.16billion to N139.42billion over the next 30 years at present level of development and values. The study concludes that the greatest risk from Barrier Island processes assessed is mainly in Eti-Osa LGA with Kuramo Waters area as the epicentre. Recommendations include the base flood elevation (BFE) and design flood elevation (DFE) to enhance the resilience of future developments. Comparative observations from the literature on the effect of groins on downdrift areas were further made to highlight new risks on the Peninsula.

Keywords: Barrier Island; Urban development; Hazard and risk evaluation; DEM; Storm surge flooding; Coastal erosion.

1. Introduction

1.1 Background

Coastal zones worldwide are acknowledged as areas of intense natural and anthropogenic processes, home to a large and expanding human population while at the same time experiencing environmental degradation (Asangwe, 2006; Population Reference Bureau - PRB, 2003). Coastlines generally are dynamic areas where three environmental zones of land, air and water converge. A striking feature of some of the world's coastlines and coastal areas are the fragile, sometimes thin accumulations of sand and vegetation that form the barrier island system along these coasts. These barrier islands which are usually sedimentary or depositional are separated from the mainland by estuaries, bays or lagoons. Unlike the stationary mainland landforms, Barrier islands naturally are unstable, eroding, migrating and rebuilding in response to winds, waves, tides, currents, sea level

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changes and other relentless ocean environment processes such as extreme episodic storm events (EESE's) (Feagin et al., 2010). Worldwide, barrier islands are in high demand for having become highly sought after locations for development and recreation. The attraction of ocean views and beaches has drawn lots of people to settle on or take vacations on barrier islands (Zhang & Leatherman, 2011). For instance, in the United States with established formal planning for development, about 12% of all the barrier islands on Atlantic and Gulf coasts are completely urbanised while 36% are heavily developed (Stutz & Pilkey, 2005).

Barrier islands which are known to exist in 10% of world's coastlines (Stutz & Pilkey, 2011) are extremely fragile, dynamic, sometimes transitory, restless and relatively young coastal geomorphic features. They are usually formed in response to these common factors namely: large sand supply, gentle sloping mainland coastal plain, and sufficient wave energy to move sand around, rising sea level and a low to the intermediate tidal range (Bush et al., 2004). Thus, they are constantly maintained and remade by the complex interaction of rivers, sediment supply, sea-level change, ocean currents, wave energy and the wind (Western Carolina University – WCU, 2005; Jack, 2003). Looking at the total length of barrier island shoreline, the United States with the highest of 405 islands has about 24% of the world's barrier islands while Madagascar, Colombia and Nigeria each has 3% of the global length of barrier islands (Stutz & Pilkey, 2011). Of its share of the global length of barrier islands, Nigeria's 800km of Atlantic coastline is mostly composed of beach ridge barrier islands (Ibe, 1988). These include the Barrier - Lagoon complex of the Lagos coastline from the Benin Republic border for 200km to the Transgressive Mud Beach east of it. This is followed by a chain of 20 or more beach ridge barriers or deltaic barrier islands (Stutz & Pilkey, 2011), extending for about 500km on the rim of Niger Delta. Next to this and extending for 85km from Imo River to Cross River estuary is the Strand Coast which for the most part is rimmed by a barrier island chain. Of these barriers, the most generally developed with human settlements are in the Lagos barriers (Ibe, 1988).

The Lagos coastline itself is rimmed in its entirety by barrier islands. These include the Badagry Island/Lighthouse Beach backed by Badagry Creek and Lighthouse Creek, Victoria Island backed by Five Cowrie Creek and Lekki Peninsula which is backed by Five Cowrie Creek, Lagos and Lekki Lagoons. Of these, Victoria Island which had experienced phenomenal erosion and lost over 1.5km of land near the eastern breakwater is the most developed and constitutes one of the important commercial and residential areas of the country (Nwilo, 1997).

Some research works have summarised the inherent dangers or challenges confronting development on coasts and barrier islands generally and particularly in the United States (Bush et al. 1996; Stutz & Pilkey, 2005; WCU, 2005; Feagin et al. 2010 and Taylor, 2014). For barrier islands, these challenges include their sandy nature, wind, waves and currents, low elevation and attendant flooding, their unstable and migratory nature, storms and storm surge flooding, coastal erosion and consequent placement of coastal defence structures to check eroding shorelines. Cumulatively, these works concluded that urban development is a major driver of environmental degradation and habitat loss on barrier islands as these developments with stabilisation projects initiated hazardous conditions, wetland losses along with sediment and geomorphic changes. Further, they observed that in the past few decades, despite escalating disaster-related losses and environmental risks of living on these islands, barrier island communities in the United States continue to grow and rebuild even after major storm disasters.

Rapid urbanisation therefore in a generally low-lying Lagos metropolis has led to the unplanned and extensive reclamation of wetlands, encroachment on natural drainage channels and unrestrained deforestation to provide land for rapid urban expansion (Abegunde, 1988). Lekki Peninsula sub-region which is on the southern flank of Lagos is part of the metropolis experiencing rapid urbanisation in recent years. Although given the name 'Lekki Peninsula', it is an island (LASG, 1980). Being a part of the Barrier-Lagoon complex (Awosika et al., 2000; Awosika et al., 1993a; Ibe, 1988; Nwilo, 1997), Lekki Peninsula is principally a large barrier island. Having an appreciable store of fragile, undeveloped land close to the highly developed high-brow and previously very erosive Victoria Island (a barrier island also), this has predisposed it to be one of the most dynamic growth areas. Since the Lekki Scheme I in 1980's by the State Government, development has accelerated including residential schemes, Lekki Free Trade Zone Phase 1 (LFTZ) and infrastructure master plan (Fig. 1.1a, b, c) and has outpaced physical planning until recently. Missing in these development activities and in the literature is the consideration of barrier island dynamics and hazards/risks from its physical processes such as erosion, devastation and flooding as shown in Plate1.1 a - e) and exemplified from barrier islands of Long Island, New York, Miami Beach, Florida, on Victoria Island and on the Peninsula itself. Appropriate planning and development which recognises the dynamic characteristics of such island and others like it as well as human needs should guide the location of development activities (Taylor, 2014) to enhance livability.

Against this background, this study sought to evaluate how existing and continuing development are at risk from the physical processes of Lekki Peninsula as a case study and how this information could be used to safeguard existing development and guide future ones on it and other developing Lagos barriers. In advanced countries, costly imageries, sophisticated analytical techniques and historical shoreline data are in use for coastal hazard evaluation. For a developing country like Nigeria which lacks these tools and funds are usually limited (Bush et al., 1999), a viable low - cost alternative approach for coastal risk evaluation becomes desirable. In this regard, the study focused on the use of free online imageries and data to augment baseline data for a low-budget evaluation of proxies of coastal processes or geo-indicators and their inherent hazards. Among the objectives are the assessment of the island physical characteristics or geo-indicators, the evaluation of the hazards of these physical processes and the risks they pose to urban development on the island. These are what are reported in this paper.

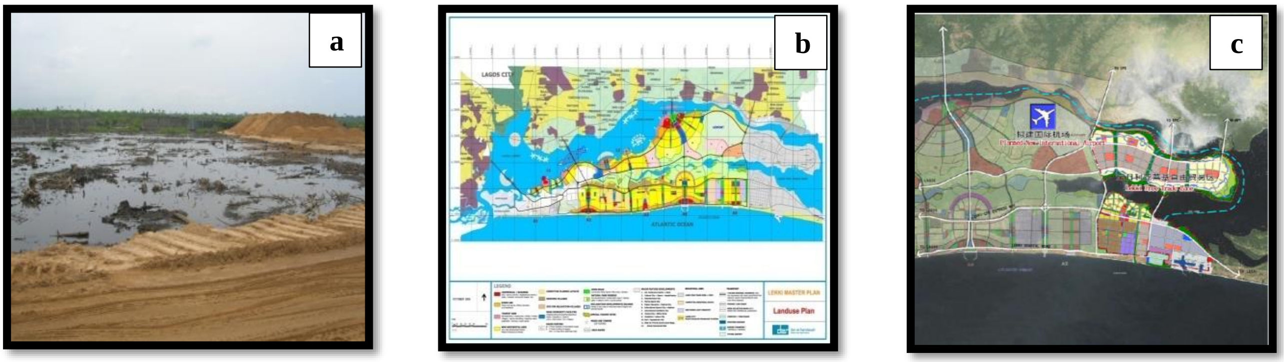


Figure 1.1a-c: a) Current development and wetland reclamation in Lekki Peninsula; b) Lekki Master Plan proposal (source: Dar al-Handasah, 2009 and c) Lekki Free Trade Zone (Source: China- Nigeria ETCZ, 2009).

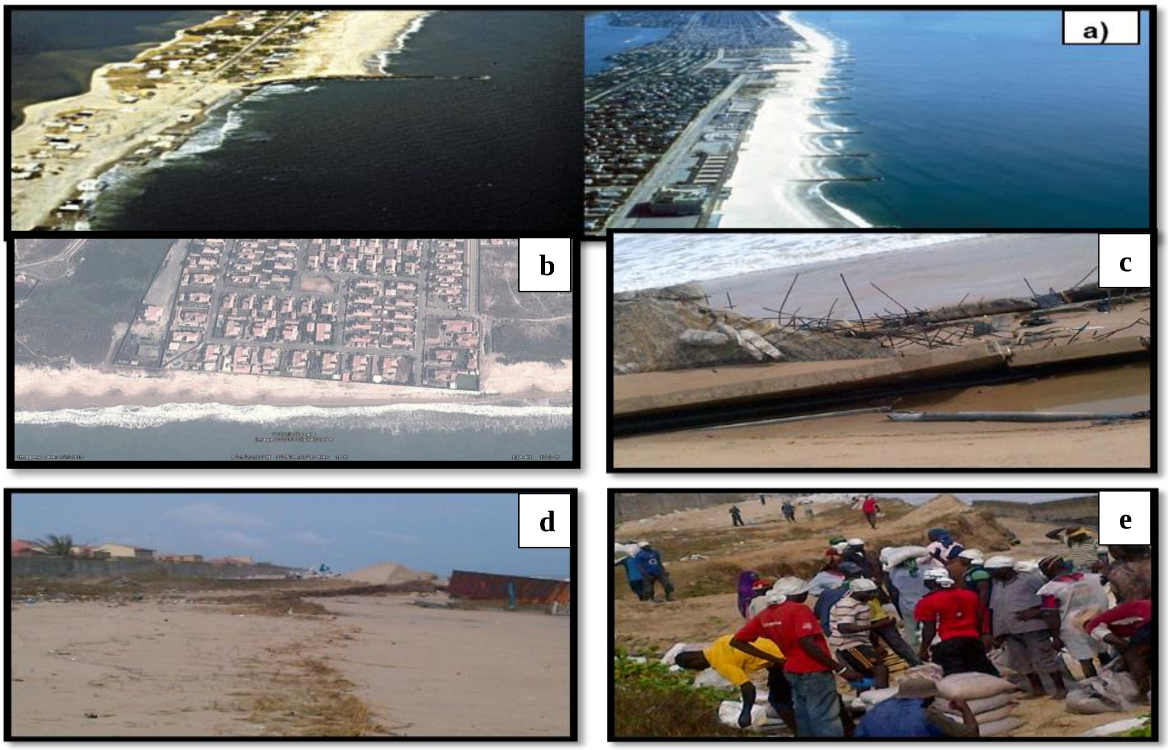


Plate 1.1a – e: Beach erosion and devastation on barrier island coastlines. a) Beach Erosion and deposition are regular features of barrier island coastlines. Groins interrupt the natural sand flow and can exacerbate erosion on downdrift side of the coastline. (Source: Tanski, 2007). b) 2013 imagery showing erosion around Goshen Beach Estate, Lekki (source: Google Earth, 2013). c) Goshen Beach Estate - remains of shallow-depth retaining wall after the ocean surge of 24-8-12, d & e- Goshen Beach Estate - devastation from the surge of 24-8-12 & workers readying sandbags as barriers to ocean surge.

1.2 Characteristics of barrier islands & geo-indicators

As their name implies, barrier islands are usually narrow and sometimes elongated, shore-parallel sandy islands placed by nature in front to protect the mainland area from direct ocean waves and storms (Fig. 1.2a, b). Having been formed by the combined action of sand deposition, winds, wave action, tides, currents, longshore drift, sea level rise and fall, the morphology of barrier islands is very dynamic, changing constantly in response to the self-same coastal processes responsible for their formation (Zhang & Leatherman, 2011; Feagin et al., 2010; Bush et al., 2004 ; Jack,2003). As dynamic sand accumulations, they are endowed with two turbulent coasts, the ocean side and lagoon side (Taylor, 2014). The ocean side is prone to strong winds, waves, storms or surges, longshore and rip currents, coastline erosion and/or deposition as well as sea level variation. On the lagoon side are usually the tidal salt marshes and wetlands. Between the beach and the lagoon side in the higher latitudes are the primary dune, the secondary dune, the back dune and the flat zone, the flats being the best location for urban development as prescribed by Mcharg (1971). The primary dune serves as the major defence against the sea and therefore intolerant of breaching with perpendicular roads or building development (Mcharg, 1971). Unlike in the higher latitudes where onshore winds play a significant role in dune formation, their role in translating beach sediments inland on the humid tropical barriers is an unsettled issue, hence beach dune development in the low latitudes are not as prominent. Thus the Nigerian coastline including Lekki Peninsula is characterised by flat beaches (Ibe, 1988). Changes in sea level, wave regime, sediment supply, storm or storm surge frequency coupled with the construction of shore protection structures (groins, seawalls, bulkheads and others) influence the behaviour of barrier islands as geomorphic features. Furthermore, conventional urban development of buildings and infrastructure involves rigid structures whose rigidity conflicts with the physical dynamics of barrier islands. Consequently, the increasing pressure on the dynamic barrier island landscapes and coupled ecosystems to become rigid as human-dominated features make them unable to render the same ecosystem services and resilience dynamics as the original settings (Stutz & Pilkey, 2005). Stated differently, urban development on barrier islands counteracts their dynamics creating problems.

Geo-indicators or island characteristics (Bush et al. 1999) which includes island width, elevation, vegetation density, beach character and configuration, shoreline stability, or rate of shoreline change and storm frequency (or heavy rainfall and storm surge frequency as is applicable here), barrier island interior geomorphology and wind can be used to estimate islands geomorphic carrying capacity. This is because island width gives a measure of available space or proximity to dynamic processes of beach erosion and waves. The rate of shoreline change or erosion along with island width is the most important measure of the long-term stability of the island in terms of sea level and sediment supply. Both enable a prediction of the 'expected lifetime' of urban development or activity on the island. Storms or heavy rainfall and storm surge are responsible for flooding and risk to human development while elevation is a measure of an island's vulnerability to flooding. Bush et al. (1999) suggest that geo-indicators provide a low-cost tool for rapid assessment of coastal hazard risk potentials either for environmental monitoring or coastal assessment. These indicators are proxies expressing the short – term coastal dynamics and representing all the elements on which the coastal processes depend. They suggest that in developing countries where funds are limited and historical shoreline position data is often lacking, geo-indicators can provide simple, qualitative tools for rapid assessment of coastal hazards and risk potential. Thus, geo – indicators can be used to evaluate risk from coastal hazards such as coastal erosion, storm surge flooding, dune loss, overwash and human induced problems, loss of critical systems, increased erosion and loss of sand supply.

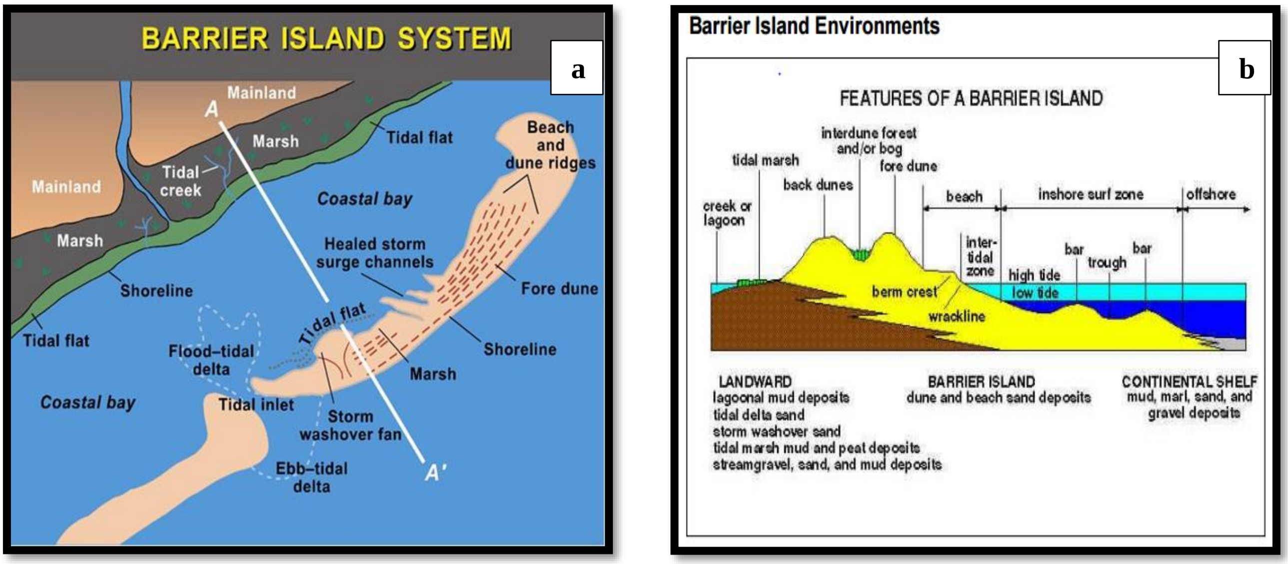


Figure 1.2 a-b: a) Typical barrier island system; b) Typical barrier island cross section – ocean to the lagoon or bay. (Source: https://sharkresearch.rsmas.miami.edu/assets/pdfs/learning-tools/).

1.3 Some effects of development on barrier islands

To situate and appreciate some of the consequences of development on barrier islands worldwide, two examples, one from Maryland, USA and the other, Victoria Islands Lagos serve to illustrate those effects. As argued by Mcharg (1971), waves normally approach the beach from an angle while water runs over the sand and recedes at right angles to the shore. By this, sand carried by the receding waves is transported through littoral drift down drift of its origin. Sand, therefore, continues to be moved in one direction and on the New Jersey Atlantic seashore, for example, this direction is southwards. Thus, groins emplaced perpendicular to the coast causes accretion/deposition on the upper end and erosion on the lower end while the northern tips of barrier islands here tend to be eroded with the southernmost tips elongated with sand deposition (Mcharg, 1971). In this light, the building of rock jetties stabilised Ocean City Inlet, Maryland but they altered the normal north - to - south sand transport by longshore currents and initiated accelerated erosion and deposition. This resulted in sand build up behind the north jetty while the sand below the south jetty was quickly eroded. This accelerated erosion has shifted Assateague Island south of the inlet about 0.8km inland (Fig. 1.3 a-c). The other example of development effects is from Victoria Island. The construction of the almost perpendicular breakwaters from 1908 to 1912 at the entrance of Lagos harbour initiated a phenomenal beach erosion of 25 - 30 m/yr. east of the eastern mole in Victoria Island (Ibe, 1988). This erosion as determined through aerial photographs saw the shoreline recede by about 2km threatening the heavy development on the frontage Ahmadu Bello Way. This was while progressive accretion was occurring on Lighthouse beach, behind the west mole (Fig.1.4a, b). Although this is currently being tamed by the construction of Eko Atlantic City project, obvious indications are that this phenomenon may have shifted further eastwards to the Peninsula.

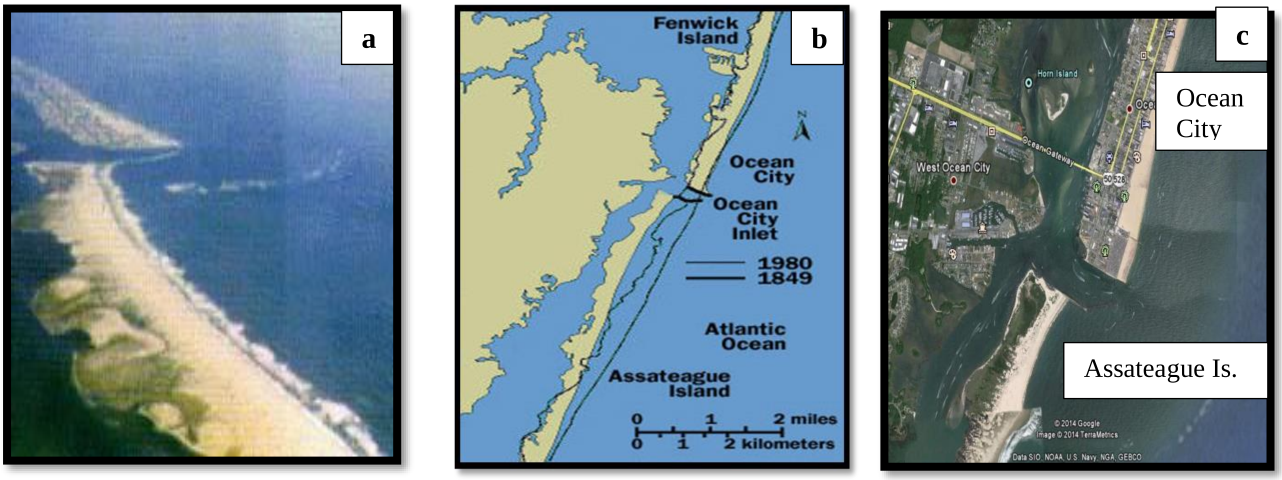


Figure 1.3 a-c: Changes in Assateague Island, Maryland (USA) as a result of accelerated erosion from the man-made rock jetties of Ocean City Inlet. a) Photo of the inlet; b) Map of the area with outline showing the position of the island in 1849 and in 1980; c) Imagery of the same island in 2010 (Sources: Freudenrich, 2014, http://science.howstuffworks.com, 2014. Google Earth, of 7-4-2010).

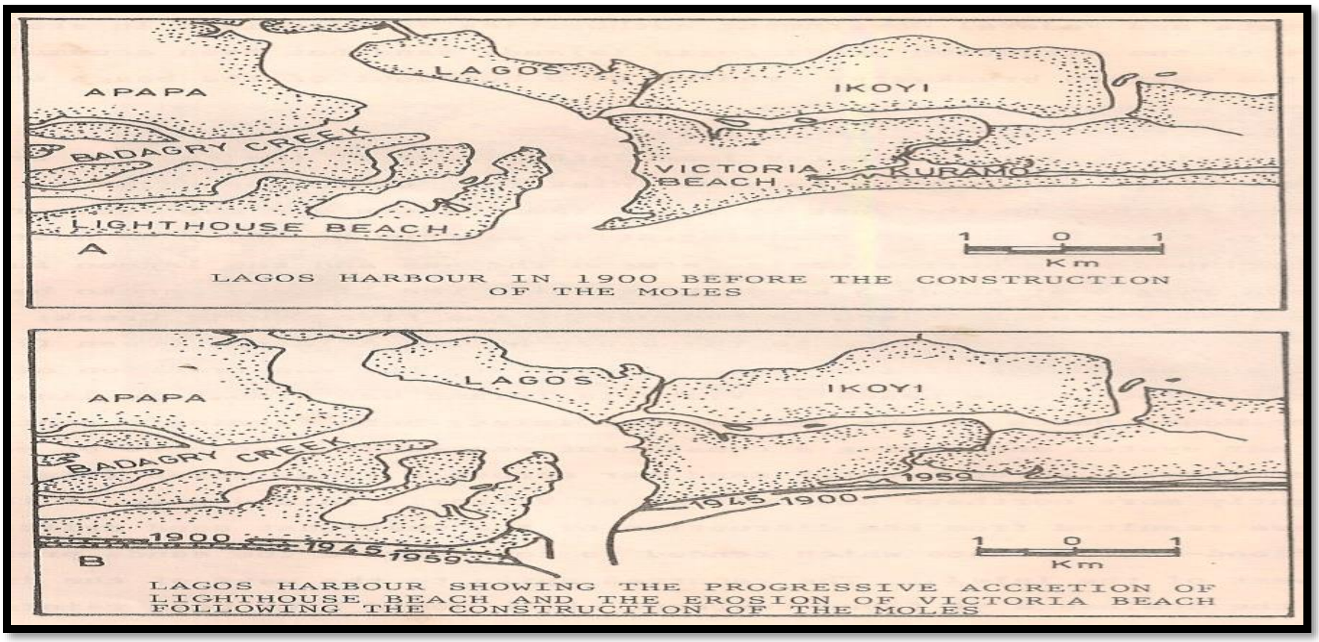


Figure 1.4: The Lagos coastline showing V.I. and entrance to Lagos harbour before (A) and after (B) the construction of the breakwaters (Source: Ibe, 1988).

2. Methods

2.1 The study area

The study is conducted on the Lekki Peninsula, a rapidly urbanising area south-east of Lagos metropolis and one of the barriers on the Lagos coastline (Fig. 2.1). It is located to the east of Victoria Island, bounded on the west by Igbosere Creek which connects Kuramo Waters to Five-Cowrie Creek. On the north, it is bounded by the Lagos and Lekki Lagoons; on the east by Ogun State. On the south, it is bordered by the Bight of Benin/Atlantic Ocean. It covers an area of about 98,000 hectares or 980km2, extending eastwards for a distance of about 100 kilometres from its western boundary. The location is at about Latitude 6^0 22'N and 6^0 37' 10"N and Longitude 3^0

25' 50" and 4^0 21' 20"E. The climate of the area as experienced in the Lagos metropolis is influenced by two air masses namely: the tropical maritime and tropical continental air masses. The former is wet and originates from the Atlantic Ocean while the latter, a warm, dry and dusty air, originates from the Sahara Desert. Two seasons are generally experienced in the area namely, rainy season (April – October) and dry season (November – March). Based on the 20 local government areas of the state, the Peninsula is composed mainly of Etiosa, Ibeju/Lekki LGA’s and a portion of Epe LGA.

Geomorphologically, Ibe (1988) suggests the barriers on the Lagos coastline of which Lekki Peninsula is one are part of the low-lying Barrier-Lagoon complex which extends from the Nigeria/Benin border eastwards for about 200km. The morphology of the complex was determined by the coastal dynamics, drainage and four interrelated coastal processes (Ibe, 1988). First, characterised by erosive beaches, there is the absence of ‘exoreic’ rivers which would have replenished from hinterland sand lost from long shore current action. This according to him explains the absence of spits and barriers developing presently. Secondly, there is a very active west to east longshore current. Thirdly, the complex has a narrow, steep continental shelf of about 30 km wide and which is indented by gullies and submarine canyons including the Avon Canyon (6^0 10'N and 3^0 55'E) and Mahin Canyon further east. This narrow continental shelf enables waves to reach the shore at higher heights and promotes the loss of near shore sediments to the gullies and canyons. Lastly, the intensity of wave action is high along the beaches due to the influence of the prevailing south-westerly winds. Also, Ibe (1988) notes that the Lekki Peninsula barrier island varies in width from ½ km to 21km and is generally aligned parallel to the Atlantic coast. The barrier beaches of the Lagos coastline have an average altitude of 0.75-5m above sea level (Abegunde, 1988). The Peninsula comprises of five geomorphologic sub-units namely: the abandoned beach ridge complex; the coastal creeks and lagoons; the swamp flats; the forested river floodplain and the Active barrier beach complex (Adepelumi, 2008).

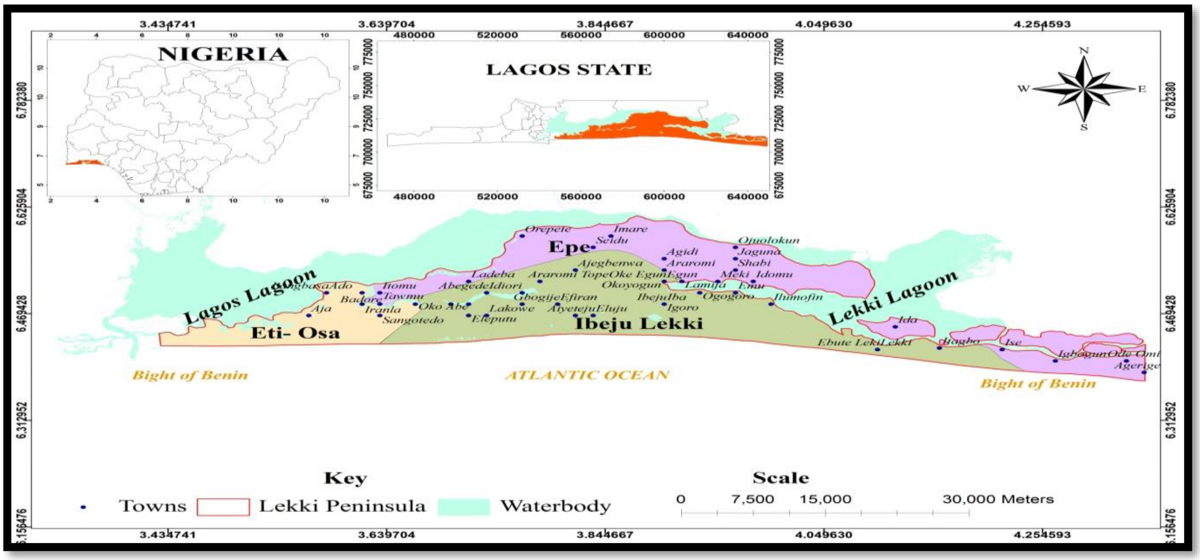


Figure 2.1: Lekki Peninsula and the LGAs’

2.2 Data acquisition & analysis

The data utilised for the study include baseline data, those on geo-indicators or island characteristics, GPS/geodetic control data as well as ancillary data. Baseline data was acquired using OSGOF 1:25,000 topographic maps of 1984/85 of Lagos NE1; Abigi NE1, NW1&2; Ibeju NE1&2, NW1&2; Ijebu-Ife SW3 and Ijebu-Ode SW4 sheets. These maps were scanned, digitised head-up, edge-matched and edited using AutoDesk Raster Design software. Geo-referencing of the digitised maps to UTM zone 31 was in ArcGIS with selected GPS control points extracted from Lagos State Geodetic Controls for the State's 'Enterprise Geographic Information System, LAGIS'. This was imported into ArcGIS 10 for all subsequent analysis. The indicators of island morphology extracted were island width, elevation and rate of shoreline erosion or recession. Island width was measured on three north-south transects corresponding to the narrowest segments in the west and east as well as on the larger portion in the middle of the island on the geo-referenced baseline map of the island of 1984/85. The western transect which later turned out to be in the most erosive segment of the island was re-measured on overlaid and geo-referenced Google Earth high resolution imageries of December 2001 and that of December 2012/January 2013. For the extraction of elevation, online, freely available CGIAR - CSI 90m SRTM digital elevation model, DEM of 2000 (WGS 84, version 4.1) was downloaded from www.cgiar-csi.org/data/srtm-90m-digital-elevation-database-v4.1.v and classified. The positional accuracy between the WGS 84 datum and the Nigerian datum (Minna datum) was assessed to ascertain the need for transformation but showed a coincidence of coordinates of both datum and the absolute height error of SRTM DEM for Lagos area was about +/-0.0904m. With this elevation data, drainage network and drainage basins or the lack thereof were generated using Arc Hydro tools in Arc Hydro Geoprocessing Tools version 2.0. Beach recession or coastal erosion was analysed on the Atlantic coastline by overlaying the geo-referenced Google imageries of December 2001 and December 2012/January 2013 and measuring to the wet/dry lines on random UTM coordinates on similar images from the southern coastline of Lagos Lagoon and Five Cowrie Creek. A minor displacement noticed between corresponding images was assumed not to invalidate the results as they are taken as qualitative indicators, not absolutes as suggested by Bush et al. (1999).

Evaluation of the potential risk to development on the island was performed by intersecting the elevation data with planar GIS or 'bathtub fill' water levels (Van de-Sande, 2012; Poulter& Halpin, 2008; Bates et al., 2005) of 0.5 – above 4.1m from datum to derive a flood hazard potential for both pluvial and marine flooding. To evaluate coastal erosion risks, the minimum (5.42m), moderate (10.25m) and maximum (22.75m) erosion rates were radiated inwards from the coastline in 10-year intervals for 30 years of the most erosive area in Eti-Osa LGA to establish the extent potentially lost if the erosion rate is unperturbed. Image mensuration (Jensen, 2007) and valuation (Otegbulu, 2013) were done to estimate socio/economic impact on buildings and road assets in Eti-Osa LGA.

3. Findings

A separate evaluation of land cover change indicates that from 0.5% in 1984, urban development or built up area had grown to 18% in the Peninsula in 2014 with Eti-Osa LGA being the most developed at about 68% and Ibeju-Lekki LGA at 7% in 2014. Transects on 1984/85 map show that island width was narrowest in the west (Maroko area, Meridian 3.44270E) at 1.76km, in the east at 1.93km and in the middle of the island at 19.1km (Fig. 3.1). This transect on Maroko area on Google imagery between 2001 and 2013 shows that island width has reduced to 1.52km by 2013 due to coastal erosion. Elevation distribution (Fig. 3.2 & Table 3.1) confirms the Peninsula as mainly low-lying with 37% at 0.5 - 3m and 63% at 3 - 5m above m.s.l. Eti-Osa LGA, the smallest of the area councils, is the most low-lying (Fig.3.3) with 0.5-3m (78%) dominant while its Atlantic coastlines are mostly at 0.5-1.5m. The heights of 3-4m dominate in Epe (62.8%) and Ibeju Lekki (59%). Extreme flood hazard potential on planar water levels (0.51-2m; Fig.3.4) was mainly in Eti-Osa LGA. Results of drainage analysis show the existence of minimal drainage basins over the Peninsula (Fig. 3.5). Results on beach erosion (Table 3.2) also show that the maximum rate of erosion occurs mainly in Eti-Osa LGA at about 22.75m yr-1 around Kuramo Waters decreasing to 5.5m yr-1 around Goshen Estate and minimal in the east (Fig. 3.6). Kuramo Waters, a formerly enclosed water body was observed to have been breached by the Atlantic Ocean in 2012. Similarly, Goshen Estate's fence was measured at 14.80m on Google Earth imagery of 17/4/2012 but had reduced to 11.21m from wet/dry or high water line in 2013 after the ocean surge of July 2012 (Plates 3.1a, b). If any doubt existed on the veracity of the erosion results, a subsequent Google Earth imagery of 5/3/2014 (Plate 3.2) clearly showed new groins constructed in this vicinity as apparent confirmation of extant serious erosion.

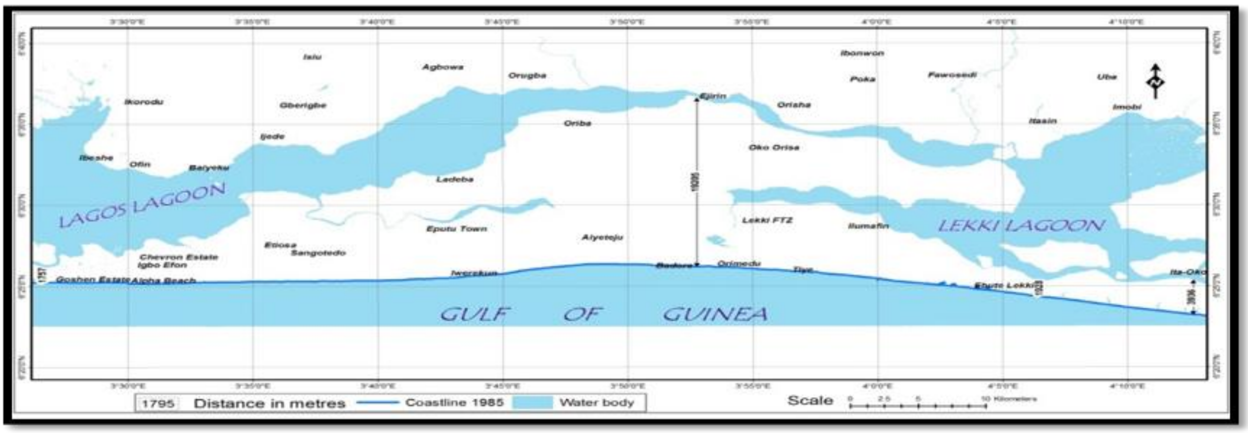


Figure 3.1: Transects of Island width in 1984/85.

Table 3.1: Spatial Distribution of elevation & percentages in LGA's (Derived from SRTM data of 2000).

	Eti-Osa LGA		**Ibeju-Lekki LGA**		**Epe LGA**	
Elevation (m)	**Area Covered(km²)**		**Area Covered(km²)**		**Area Covered(km²)**	
0-0.5	0.00	0.0%	0.06	0.0%	0.00	0.0%
0.5-1	1.60	1.1%	1.41	0.3%	0.71	0.2%
1-1.5	18.98	13.3%	3.38	0.7%	4.91	1.5%
1.5-2	27.09	19.0%	9.89	2.1%	14.28	4.3%
2.0-3.0	64.63	45.3%	122.11	26.1%	77.62	23.1%
3.0-4.0	27.48	19.2%	276.79	59.2%	210.54	62.8%
4.0-5.0	3.03	2.1%	53.64	11.5%	27.23	8.1%
5.0-6.0	0.00	0.0%	0.00	0.0%	0.23	0.1%
Total	142.81		467.28		335.52	

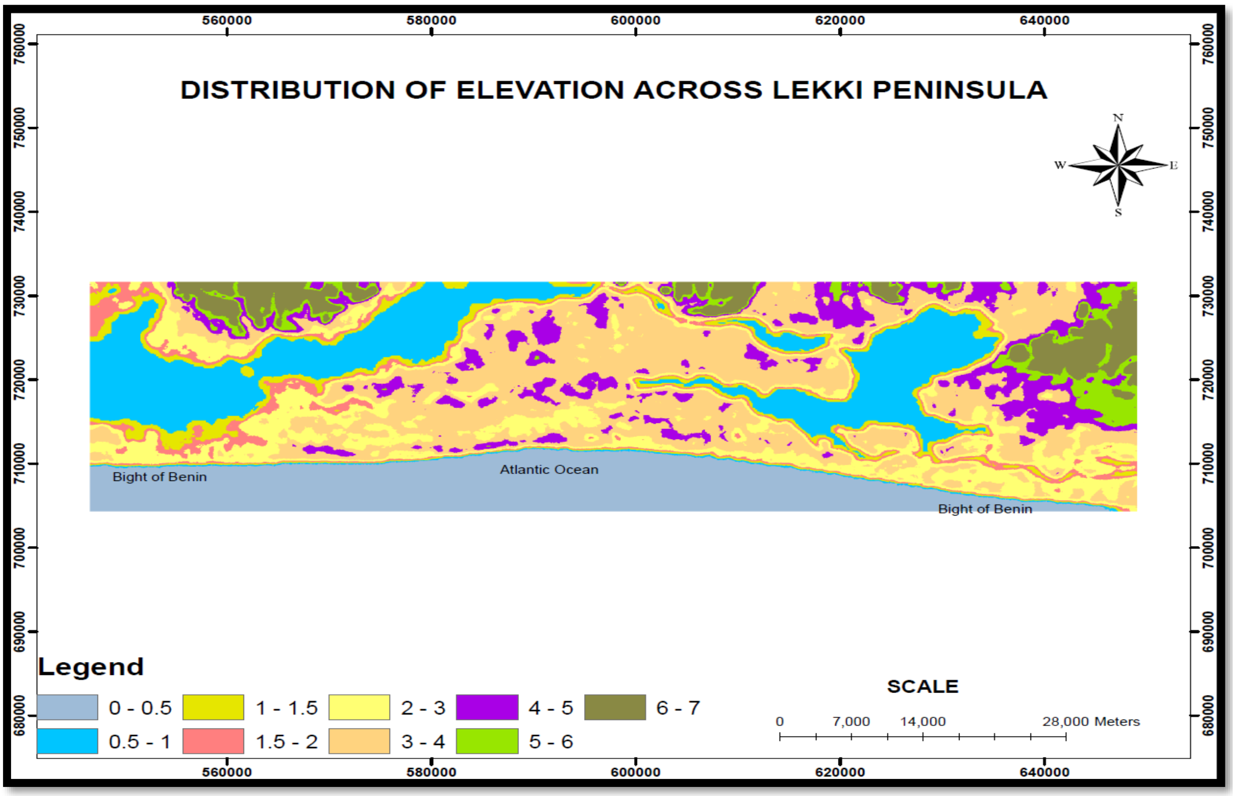
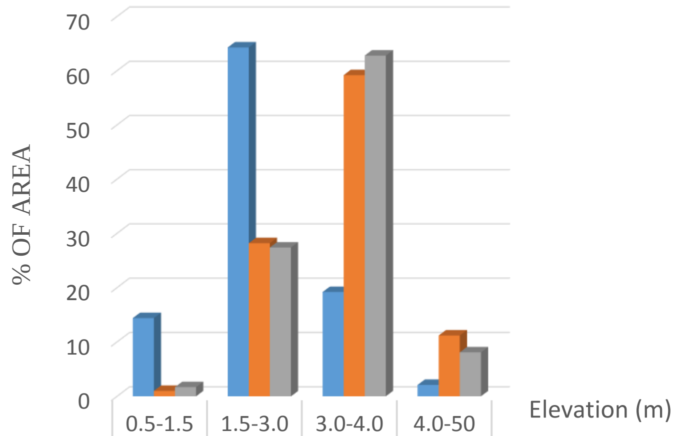


Figure 3.2: The distribution of elevation on Lekki Peninsula (Source: SRTM DEM data).



	0.5-1.5	1.5-3.0	3.0-4.0	4.0-50
ETIOSA	14.4	64.3	19.2	2.1
IBEJU LEKKI	1	28.2	59.2	11.2
EPE	1.7	27.4	62.8	8.1

Figure 3.3: Histogram plot of elevations across LGA's.

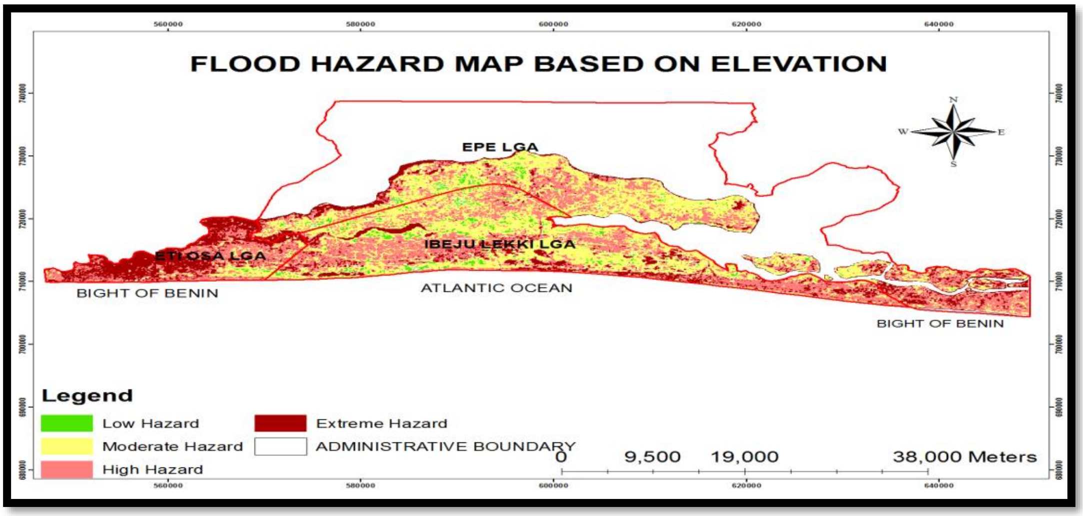


Figure 3.4: Flood hazard potential for both pluvial & marine flood based on planar water levels/elevation (0.51 – 2m = extreme hazard).

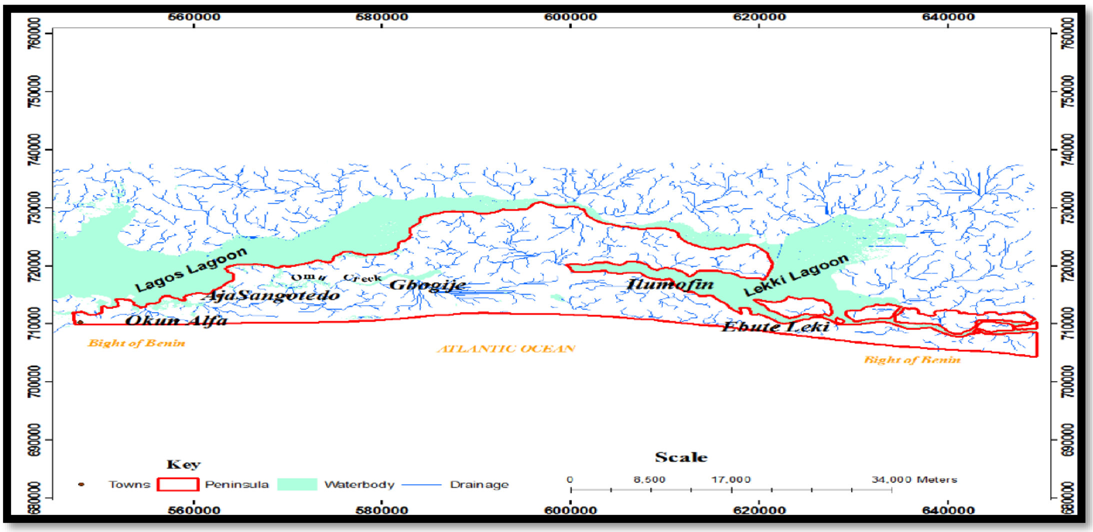


Figure.3.5: Surface drainage network and drainage basins or lack of in the Peninsula (Generated from SRTM DEM).

Table 3. 2 Points of maximum erosion in Etiosa LGA (Derived from Google imagery of 2001 & 2013).

POINTS OF EROSION MEASUREMENTS (All in Eti-Osa LGA)

S/N	Length (m)	Meridian (°E) along segment	Annual erosion rate (m)
1	273	3.4308	22.75
2	197	3.4336	16.42
3	166	3.4382	13.83
4	124	3.4427	10.33
5	110	3.4472	9.17
6	105	3.4518	8.75
7	99	3.4563	8.25
8	95	3.4607	7.92
9	94	3.4651	7.83
10	65	3.4698	5.42
11	82	3.4741	6.83
12	66	3.4789	5.50

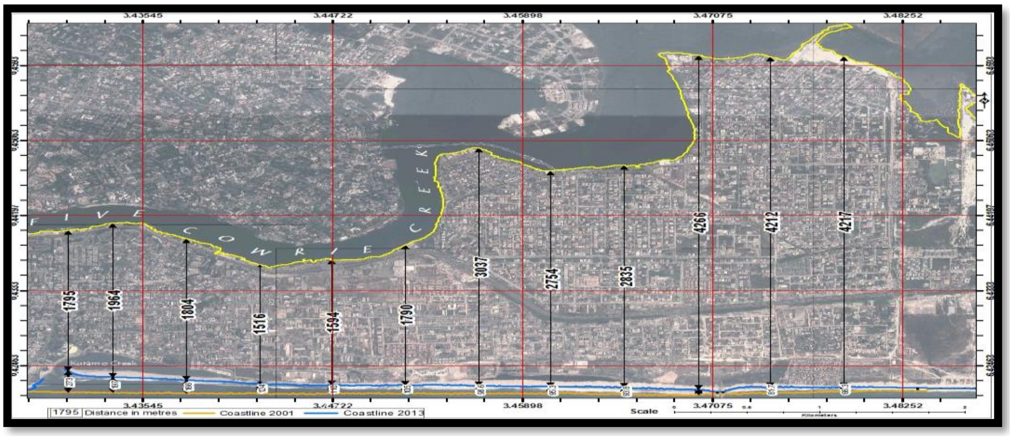


Fig. 3.6 Areas of maximum erosion in Etiosa LGA (Derived from Google imagery 2001 & 2013).

Plate 3.1a, b. Goshen Estate in 2012 and 2013 showing distances of the fence from the coastline. Note the beach configuration before the construction of groins; a. Goshen Estate in 2012 showing distance of fence from the coastline -19.63m & wet/dry line - 14.80m; b. in 2013 showing distance of fence from coastline – 16.05m & wet/dry line – 11.21m (after erosion/ocean surge of July 2012 (Imagery source: Google Earth, 2012 & 2013).

Plate 3.2. Google imagery of 5/3/2014 showing newly constructed groins around Goshen Estate and new u-shaped erosion/accretion between the groins. The new groins are apparent confirmation of extant serious erosion.

The results of coastal erosion risk evaluation show that the minimum land area potentially eroded in Eti-Osa LGA by the year 2023 is 36ha, 64ha in 2033 and 94ha in 2043 while the maximum in 2043 is 408ha if the erosion remains unchecked and at these rates. Also, the minimum to maximum potential economic losses in building and road assets in this area range from N1.16billion in 2023 to N139.42 billion in 2043 in today's values.

4. Discussion and Recommendations

The transect of island width on Meridian 3.44270E in Eti-Osa LGA showed a reduction of 0.12km between 2001 and 2013, occasioned by shoreline erosion. As a measure of life expectancy of the island, this is indicative of the space left before the island is severed by erosive forces if the problem is left unattended to. The spatial distribution of heights in the three council areas amply confirms the Peninsula as generally low lying. The absence of discernible direction of slope, definitive watersheds and drainage basins lends credence to this low-lying nature. These results comparatively reveal that Eti-Osa LGA, which is the most developed currently is the lowest - lying of the councils in the Peninsula with heights of 0.5 - 3m being dominant. The flood hazard map based on 'bathtub-fill' method/elevation shows that most of the area of extreme flood hazard potential (0.51-2m) is in Eti-Osa LGA. This means that about 50% of the council is 2m and below, hence flood waters of slightly above 2m (above m.s.l) will likely inundate 50% of the council. Epe LGA is the council with the highest percentage of areas of the height of 3 - 4m followed closely by Ibeju - Lekki LGA. These translate into areas of potentially less flood hazard than in Eti-Osa LGA. Contrary to the elevation range of 5 - 15m used in the drainage master plan in the new Lekki Infrastructure Master Plan (Dar al - Handasah, 2009), there is hardly any significant area in the Peninsula above 5m height. The sand filling of Lekki Phase 1 and the subsequent piecemeal sand filling of other areas like Lekki-Epe Expressway disorganised the minimal drainage courses which existed previously in Eti-Osa (Dar al- Handasah, 2009). As such, Jakande Estate, Lekki, excised villages of Maiyegun, Aro, Igbo Efon and Okun Alfa, for example, are severely inundated from pluvial flooding as they are generally lying lower than the Expressway and advisably cannot drain to the Atlantic Ocean. It is conceivable that in time, the state may undertake to buy out the owners of these places to properly raise the levels well above the expressway to drain to the lagoons. Low elevation with hardly any discernible direction of slope, high water table and a severe lack of drainage heads make comprehensive surface drainage and sewer system for the Peninsula herculean ventures. This is what compelled the recommendation of a cluster of eight (8) sewage treatment plants for the Peninsula with requisite lift stations to discharge effluent to the lagoons (Dar al - Handasah, 2009). Among the requirements for recommending flood resilient levels for new development given low elevation are the Base Flood Elevation (BFE) and Design Flood Elevation (DFE). Based on the elevation analysis and flooding evaluation, a BFE of 3.1m above m.s.l and a DFE of 3.7m above m.s.l for new developments are suggested. For flood resilience and to save lives, new buildings should be elevated off the ground at least 3m above the suggested DFE.

The evaluation of beach recession shows that erosion and beach recession have clearly shifted eastwards to areas of the Peninsula which were reported in Ibe (1988) to be experiencing accretion at the time. The effect is that at the average and maximum rates of erosion occurring in this vicinity, erosion at the narrowest segment of 1.52km leaves this area with a potential lifespan of 66 - 142 years from 2013 if the erosion remains unchecked. The evaluation of risks from coastal erosion underlines the elevated risks Goshen Estate, buildings and road infrastructure in the area are exposed to from both ocean surge and continued erosion and helps to illuminate the need for proactive planning for emergency towards the safety of residents of the area. It also illuminates the potential economic losses to property owners in this vicinity as well as potential losses to the construction industry generally for the loss of beach lands here which have been earmarked for recreational development in the current infrastructure master plan (Dar al – Handasah, 2009). Further, it draws attention to the potential loss of livelihoods of beach recreation operators in this area as the beaches are among the first line area to be potentially eroded. The potential risks outlined should form part of the wake-up call for planning for emergencies in this area. Planning for emergencies in the area is necessary because as determined from literature in the course of this study, regardless of the coastal protection measures being undertaken or contemplated, hard engineering protection measures quite often shifts the erosion problem down drift from its location. Besides, coastal erosion as part of barrier island's physical processes is inevitable regardless of measures undertaken.

5. New challenges

As is indicated above, some groins were shown to have been constructed on the coastline around Goshen Estate by March 2013. On Friday, June 3, 2016, The Guardian Newspaper (www.guardian.ng) ran an editorial based on the previous briefing by the Lagos State Commissioner for Waterfront Infrastructure Development titled ‘Taming Ocean Surge in Lagos’. This was to the effect that the state authorities had earmarked N36billion for the construction of 18 groins at 40m intervals between Goshen Estate and Alpha Beach to the east at the cost of N2billion per groin. To be certain on the actual situation on the ground, a check on Google Earth imagery of 11/5/2016 revealed sixteen (16) groins spaced about 400m have been constructed from Goshen Estate past Maiyegun Beach towards Alpha Beach (Plate 5.1).

The most compelling question on this huge investment is will groins tame ocean surge and erosion on the Peninsula? Evidence from literature makes this doubtful. In their natural states, beaches and barrier islands are resilient landforms having been made to absorb and dissipate the energy of breaking ocean waves by shifting and changing in shape (eroding and accreting) in response to ocean forces and sea level changes (Watson and Adams, 2011). Where development intervenes in this process as in Lekki Peninsula, these processes transform into hazards requiring solutions to protect the coastline. Among the common structural measures or 'hard

Plate 5.1 Imagery of 16 groins spaced about 400m from Goshen Estate towards Alpha beach as at May 11, 2016 (source: Google Earth, 2016).

Engineering structures' are groins, seawalls and bulkheads, revetments, jetties, geotextile containers and sometimes, breakwaters. Groins are rock structures built perpendicular to the shore to intercept the littoral migration of beach sand. It has been observed that solid structures often reflect incoming waves sharply causing greater turbulence and increased erosion downdrift from their location (Watson & Adams, 2011).

Under these circumstances, to gain a broader insight, it became instructive to illustrate an example of a similar situation on developed barriers of Long Island, New York, USA. It is expected that an enduring solution can be found and implemented in this context if possible. Where have groins then abated erosion? Maybe this can happen on Lagos coastline but not on the coastline of the barriers of Long Island, New York. As reported in Tanski (2007) and Coch (2015), Long Island's Atlantic shoreline in New York is occupied by a series of dynamic barrier islands, some heavily developed while some are natural resource areas. After the 1938 hurricane, coastal engineering structures including groins, sea walls and jetties were viewed as means to increase beach width to minimise storm damage and to stabilise storm-cut inlets on Long Island (Coch, 2015; US Beach Erosion Board, 1946). Jetties were thus built to stabilise inlets such as Shinnecock Inlet in Southampton (Plate 5.2) and others. These jetties reduced the natural westward longshore sand movement along the south shore of Long Island resulting in sand accumulation on the up-drift or east side while the beach on the down-drift or west side of the inlet was severely eroded. The building of many groins to trap sand moving along the shore to widen local beaches and as storm protection measures, Coch (2015) concluded resulted in severe beach erosion of the western end of Long Island (Plates 5.3 & 5.4).

Plate 5.2: Erosion resulting from stabilisation of Shinnecock Inlet in Southampton, Long Island, New York.
The up-drift side of the inlet (right) is accumulating sand against the jetty. The lack of sand supply on the down-drift side of the inlet causes erosion (source: Coch, N.K., 2015 & Google Earth, 2015; imagery date – 24-5-2015).

Plate 5.3 Aerial view of Coney Island at the western end of Long Island, NY. Relatively little sand manages to get here from its source in eastern Long Island. (Source: Coch, N.K., 2015).

Plate 5.4 Even with groins, seawalls & palpable deposition, erosion is alive on Long Island barriers and the Cabana complex was at risk on 12-10-2014. Imagery captured on 12-10-2016. (source: Google Earth, 2016).

Clearly, if groins have failed to abate coastal erosion over the years on Long Island, New York and elsewhere (Escudero, Silva & Mendoza, 2014; Gomes & da Silva, 2014), the prospect of it doing so on Lekki Peninsula is seriously in doubt. In this regard, the pattern of effects of groins on Long Island, New York is beginning to similarly manifest on Lekki Peninsula shoreline. For instance, in about $2^{1/2}$ years since the construction around Goshen Estate, the u-shaped shoreline formation characteristic of groin formation on imageries and aerial photos has emerged on the previously almost linear shoreline of the Peninsula.

Furthermore, the imagery of 11-5-2016 still shows the back fence of this Estate as still on elevating risk of being washed away with almost no noticeable beach accretion. While these may be the case, non-structural or 'soft' coastal and barrier island protection measures are recommended as part of a suite of solutions instead of a one-off approach with groins. These actions include among others dune restoration and beach nourishment, vegetative shore protection, coastal wetland restoration/conservation and substantial setback distances from the shoreline. Others include hybrid stabilisation techniques involving nourishment, vegetative techniques involving the planting of dune grasses and other native shoreline species and geotextile measures are also employed (Watson and Adams, 2011). Although beach nourishment is expensive and failed severally in Victoria Island in the past, evidence in literature shows that many developed countries including the Netherlands (Bakker et al., 2012) have robust beach replenishment programs in shoring up the beach berm and dunes. Finally, despite the suggested measures and any other being implemented for the resilience of development in the Peninsula, it needs to be re-emphasized that low elevation, coastal erosion, flooding (pluvial and marine) are unchangeable natural processes of this barrier island and others and thus their life cycle. Protection measures can only buy time but not stop their mobility. With sea level rise as predicted, these processes are expected to exacerbate. Part of our overall resilience strategy should, therefore, be the option of 'retreat' when possible.

6. Conclusion

As a basis for understanding the sister barriers on the Lagos coastline, this study has shown a low budget integration of free/online high resolution imagery data, SRTM DEM and GIS techniques to assess geo-indicators (or proxies of coastal processes) and evaluate some environmental risks to urban development on Lekki Peninsula from hazards inherent in its physical processes. It has also demonstrated simple, repeatable, approaches to pre-disaster coastal risk assessment. Findings have underscored the area as narrow in some locations, low-lying, prone to pluvial flooding as a result and afflicted in some parts by rapid shoreline erosion. These have also helped to establish that some of the risks to urban development in the Peninsula are those tied to its dynamic characteristics as a barrier island. Appropriate suggestions for the resilience of new developments have been made. Furthermore, the study provides actionable spatial information which can be part of the decision-support tool in evaluating urban development on the Peninsula and sister Lagos coastline barriers. An area for further inquiry is a continuous evaluation of the physical effects, gains/losses on the coastline from the groins so far emplaced on the Peninsula.

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Assessment of Building Maintenance Projects Success Factors in Developing Countries

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Abstract

Building maintenance projects have been characterized by poor quality delivery, which leads to client dissatisfaction. The maintenance contractor's personnel evolve around the uncertainties that surround maintenance decisions, which make the success of a maintenance project dicey. Hence, this study seeks to identify critical success factors that determine the performance outcome of building maintenance projects in Lagos State, Nigeria. A quantitative research approach was adopted for the study using a questionnaire survey for data collection. Descriptive and inferential statistics were employed for the analysis of the data collected. The findings of the study indicate that the eighteen identified factors can be grouped under six critical success factors named team integration and knowledge transfer, project learning and maintenance methodology, stakeholders' early project assessment, planning and control, information and communication management within project stakeholders, and quality and risk control. The effective management of these factors will improve building maintenance project's outcomes in Nigeria and adaptable for other similar developing countries.

Keywords: Building maintenance; Developing countries; Maintenance contractors; Project success factors.

1. Introduction

The importance of the buildings and its auxiliary facilities to human existence and their activities cannot be overemphasized. Though a building structure should be built to last, its longevity still depends on the level of care channelled into it. Effective maintenance is required to sustain the original purpose and intent of the building in terms of functions, aesthetics, health and safety, and so on. As the economy of a nation grows the need for maintenance functions increases (Tan, Shen, and Langston, 2012). Therefore, every growing economy must strengthen its maintenance output in the construction industry to meet the changing business environment. Factors that affect the maintenance market, according to Tan, Shen, and Langston (2012), are increasing number of ageing buildings, obsolescence and adaptive reuse, legislation, sustainability, and social responsibility. Maintenance is defined as "a combination of any actions carried out to retain an item in, or restore it to an acceptable condition" (BSI 1984, 3811). However, maintenance, according to Olanrewaju (2010 : 201) is "the processes and services to preserve, repair, protect and care for a building fabric and engineering services after completion, repair, refurbishment or replacement to current standards to enable it to serve its intended function throughout its entire lifespan without drastically upsetting its basic features and use". From the definitions, it can be seen that maintenance is a vital component of an organisation's existence in relation to its asset management.

In the study of Edmond, Lam Albert, and Chan Daniel (2010), they affirm that maintenance of existing building assets has been considered a top priority in most client

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organisations in their project planning. Most organisations have realized the efficacy of maintenance functions in their day-to-day activities and in the continuity of their production line to avoid a shutdown. These maintenance functions, whether services, repair, replacement, or cleaning, is a project to an organisation. The characteristic of the maintenance project depends greatly on the nature of the work to be executed. This also determines the mode of execution of the project, whether through in-house or outsourced contracting. No matter the mode of execution of the project, a successful completion of the project is paramount. Project success is seen as meeting goals and objectives as prescribed in the project plan, while a successful project means that the project has accomplished its technical performance, maintained its schedule, and remained within budgetary costs (Frimpong, Oluwoye, and Crawford 2003). Therefore, a project is considered successful if it meets the time criterion, monetary criterion, effectiveness criterion, and client satisfaction criterion set for it.

Unfortunately, building maintenance projects have been characterised by poor quality and delivery, which has led many times to client dissatisfaction. Also, the maintenance contractor and personnel evolve around the uncertainty that surrounds maintenance decision-making platform, which makes the success of the maintenance projects dicey. According to Mukelasi, Zawawii, Kamaruzzaman, Ithnin, and Zulkaranain (2012), the administration of maintenance management is not effective and efficient resulting in defective facilities and poor services. Obviously, maintenance approach altitude has been more reactive rather than proactive in nature without the interest of customer satisfaction (Mukelasi et al. 2012). This has resulted in the appalling conditions of buildings and auxiliary facilities, for example in Nigeria (Zubairu 2000; Adebayo 1991; Adenuga 2008; Adenuga, Olufowobi, and Raheem 2010; Okolie 2011). Therefore, to improve and retain the state of conditions of infrastructural facilities, it is paramount to improve maintenance management administration. Meaning that, the factors that can contribute to the success of building maintenance projects need to be identified. The identification of the constraints and the critical success factors (CSFs) in business can enhance management strategy and performance (Mukelasi et al. 2012). This will reduce the probability of failure during the execution of the project when all risks are well managed (Mukelasi et al. 2012). Therefore, maintenance project execution must be viewed and approach in an appropriate procedure to achieve success. The successful completion of maintenance projects will increase client satisfaction and organisational image of maintenance firms and the betterment of the built environment.

Buildings must be retained in a functional state to meet the needs of the occupants through an effective and efficient maintenance practice and execution. For this to be achievable in reality the critical success factors that can influence the improving of the maintenance workforce needs to be identified. Therefore, this study seeks to identify the critical success factors (CSFs) that determine the performance outcome of building maintenance projects in developing countries using Lagos, Nigeria as a case.

The study is divided into five sections, the first section is the introductory part that highlights the purpose of the study; the second section is the review of literature where previous related studies to the subject were presented; follow by the research method section that show the approach of data collection and analysis; while the fourth section deals with the discussion of the findings in relation to the literature review and the final part is the conclusion section.

2. Critical Success Factors (CSFs) Conceptual Review

Identifying critical success factors at the early stage of a project is paramount to the successful completion of a construction project. This couples with the consideration that there are some factors that influence project performance within the project environments. Critical success factors (CSF) are employed to measure organizational excellence (Mukelasi et al. 2012). According to Mukelasi et al. (2012), CSF is vital for building maintenance project because it can identify causes of project failure and also improve performance. Hence, these certain major factors must be well planned to achieve a successful project delivery.

Project success factors has been a major research area among the academia in the field of project management. Various contributors have established different factors that determine project success, such as Belassi and Tukel (1996); Divalcar and Subramanian (2009); Edmond, Lam Albert, and Chan Daniel (2010); and Straub (2011) (see Table 1). In 1996, Belassi and Tukel proposed a framework for determining critical success/failure factors in a project. Their findings reveal that critical factors have diverse ways of influencing the project outcome in different project environments. That means that the success factors for different projects may be diverse and unique in accordance to the projects' characteristics. The results of the study of Belassi and Tukel (1996) show that the project managers' managerial skills, team members' commitment and technical background, project attributes, and environmental factors are as viable and can be as critical as the organisational factors' in information technology and in manufacturing projects, managerial skills are the critical factors while environmental factors (economic and weather) mostly affect construction projects.

Edmond, Lam Albert, and Chan Daniel (2010) conducted an empirical study among maintenance contractors in the Hong Kong construction industry. They considered the time, cost, quality, functionality, safety, and environmental friendliness as the key performance indicators (KPIs) for building maintenance projects. But Belassi and Tukel (1996) attest that when time is considered as a KPI, the project manager's skills and communication between the team members becomes critical. This is reiterated by Straub (2011); communication and empathy skills toward the client are necessary for all consultancy activities. Basically, there exists a complex interaction between project variables which necessitate the need for further investigation of critical factors that determine project success in different project environments.

Straub considers maintenance contractors as service innovators; the study looks at certain attributes that determines the success of a maintenance project in relation to the personality of the contractor. Straub (2011) views that maintenance contractors must acquire more knowledge to ascertain the rate or level of deterioration of components and be able to give maintenance advice and cost implications. In addition, for a successful maintenance project, the ability to design, plan, and calculate maintenance scenarios, and performance measurement plans are vital (Straub 2011). Integrity, honesty, and coordination skills are also identified as necessary attributes (Straub 2011).

A study carried out by Divalcar and Subramanian (2009) identified nineteen project success factors that were reduced to three critical categories: role of project participants, planning; monitoring and feedback; and decision making, approval, and implementation. Further, seventy-seven factors were identified and classified under seven groups as project management-related factors, procurement-related factors, client-related factors, and business-related factors in the work of Saqib, Faruoqui, and Lodi (2008). The findings of their study show that the ten CSF of a project were decision-making effectiveness, project manager's experience, contractor's cash flow, contractor experience, timely decision by an owner/owner's representative, site management, supervision, planning effort, prior project management experience, and the client's ability to make decisions out of the seventy-seven identified factors. Also, Saqib, Faruoqui, and Lodi (2008) added that the top five CFS groups that influence project success were contractor-related factors, project manager-related factors, procurement-related factors, design team-related factors, and project management-related factors.

Bamber, Sharp, and Hides (1999) developed a conceptual framework for a successful implementation of Total Productive Maintenance (TPM) with nine factors namely, the existing organisation, measures of performance, alignment to company mission, the involvement of people, an implementation plan, knowledge and beliefs, time allocation for implementation, management commitment, motivation of management and workforce. From another point of view, Al-Hammad and Assaf (1996) considered the performance of maintenance contractors in Saudi Arabia from the perception of building owners and the maintenance contractors. According to the study, the building owners believed that factors that determine the successful performance of the maintenance contractors were proper planning and scheduling, safety precautions, technical competence, and workmanship while the contractors attested that proper planning and scheduling, safety precaution, subcontracting control, efficient administration, availability of equipment and facilities, and technical competence were the CSF needed to achieve a successful project delivery. Wahid and Corner (2009) stated that the composition of top management and employees, the reward system, teamwork, continuous improvement, understanding of International Standards Organisation (ISO), measurement of performance and communication are all critical success factors for ISO 9000 maintenance in the studied organisation.

Also, in the study of Mukelasi, Zawawii, Kamaruzzaman, Ithnin, and Zulkaranain (2012), the CSFs for building maintenance management of local authority in Malaysia were identified as leadership, culture, structure, roles and responsibilities, system infrastructure, and measurement. In their work, leadership relates to human capital, resources and relations which must consist of commitment, identification with the organisation, mutual trust, cooperation and future optimism. They further term culture as the nature of the maintenance work which entails the organizational practices, climate and norms, internal competence and integration, history and tools, conception and work demand. The organisational cultural elements culminate to organisation performance (Mukelasi et al. 2012). Also, the organisational structure is the division of responsibilities within the system as in top management and operational functions and physical inspection. According to Mukelasi et al. (2012) work policy will enhance a successful maintenance work system. Maintenance organisations must also utilize their system infrastructure which comprises resources, technology, management control, procedures and strategy to their advantage to achieve a positive project outcome (Mukelasi et al. 2012). In addition, project outcome needs to be measured whether it meets users' expectations in terms of quality, speed, reliability, safety, function and comfort (Mukelasi et al. 2012).

Ghanaee and Pourezzat, (2013) examined the critical success factors for urban residential renovation projects from the perspective of experts and urban managers. The findings of the study show four CSFs cluster of twelve factors as enabling factors prerequisites, requirements and facilitating factors.

In 2014, Tan, Shen, Langston, Lu and Yam studied the critical success factors for building maintenance business in Hong Kong. A total of eight CSFs was identified, such as maintenance service, organisation management, certification, people, relationship, technology, marketing, innovation and sustainability, while the two most relative principal CSFs are maintenance service and organisation, and project management (Tan et al., 2014). Their study also indicates client's satisfaction, certification of company, reliability of service, quality of service, and company reputation as elemental factors that determine building maintenance business success. Furthermore, Tucker, Turley, and Holgate, (2014) investigate the critical success factors of an effective repairs and maintenance service for social housing in the UK. The five top ranking CSFs found are stakeholder opinion, value for money, service standards, performance and continuous improvement. In support of these findings, Njuangang, Liyanage, and Akintoye, (2015) identified eight critical success factors to key performance measures to control maintenance-associated hospital-acquired infections (HAIs) as maintenance resource availability, maintenance strategies, infection control practices, risk assessment, liaison and communication with ICT, service level agreement, staff education, and customer satisfaction. Njuangang, Liyanage, and Akintoye, (2015) in their study stated that close collaboration and communication between the team are vital CSFs, and that customer satisfaction is an underdeveloped CSF.

Table 1: Summary of CSFs conceptual review

Author(s)	Study Focus	Critical Project Success Factors
Al-Hammad and Assaf (1996)	Maintenance Contractors	Providing proper planning and scheduling, providing safety precaution, subcontracting control, providing efficient administration, making required equipment and facilities available, ensuring technical competence, delivering material, and providing suggestions on cost cutting
Bamber, Sharp and Hides (1999)	Total Productive Maintenance	The existing organization, measure of performance, alignment of company mission, the involvement of people, an implementation plan, knowledge and beliefs, time allocation for implementation, management commitment, motivation management, and workforce
Al-Zahrani (2001)	Maintenance Auditing	Organisation and human resources, material management, work planning and scheduling, work accomplishment, information technology and appraisal, workload identification, and performance measures
Hua, Sher and Pheng (2005)	Communication between Client/Maintenance Contractors	Checking information with users, use of appropriate visualization techniques, sufficient human resources, timing of information, clients' feedback, working experience, clients' attitudes, straightforward work requests, and contractor's suggestion matching interests of clients
Ali et al. (2006)	Reactive Maintenance	Knowledge sharing, quality of information
Saqib, Faruoqi and Lodi (2008)	Construction projects	Decision-making effectiveness, project manager’s experience, contractor’s cash flow, contractor experience, timely decision by an owner/owner’s representative, site management, supervision, planning effort, prior project management experience, and client’s ability to make decision
Divalcar and Subramanian (2009)	Construction Project (time monitoring)	Role of project participants, planning, monitoring and feedback, decision making, approval, and implementation
Edmond, Lam Albert and Chan Daniel (2010)	Key Performance Indicator in Maintenance Project	Time, cost, quality, functionality, safety, and environmental friendliness
Straub (2011)	Innovation in Maintenance Contracting	Knowledge and competencies in calculations of costs, design of maintenance scenarios and performance measurement plans, integrity and honesty, coordination skills, communication, and empathy skills

Though the findings of some of the reviewed literatures were similar, contrary opinions are expressed in this subject area due to the uniqueness of the project environment. This change in the success factors are the rapid changes currently experienced in the business environment, according to Belassi and Tukel (1996). This makes the need to investigate the issues of CSFs in maintenance projects paramount in different domains (see Table 1). Therefore, a different project environment in a developing nation is considered in this study. The factors that determine the maintenance project’s success in Lagos, Nigeria, from the perception of the clients, maintenance contractors, and the consultants were viewed to contribute to the existing literature.

3. Research Method

To achieve the purpose of the study, a review of literature on critical project success factors was conducted. This involved the identification of various factors that can contribute to a successful completion of a project. About eighty factors were identified from the literature in general. The identified factors were then reduced by an expert panel in the field of maintenance contracting, which included maintenance manager/officers, maintenance contractors, and academics with a research focus on maintenance activities, through a questionnaire Survey. The panelists were mandated to identify those factors that are most critical to a maintenance project considering its unique nature. The factors were reduced to eighteen, which was considered appropriate for the study. A structured questionnaire was developed to facilitate data collection and to ensure consistency in the elements examined. The questions were designed as statements seeking a participant’s level of agreement to identify factors that determine the successful delivery of a maintenance project; the responses were based on a five-point Likert scale where 1.00-1.50 is not critical; 1.51-2.50 is less critical; 2.51-3.50 is critical; 3.51-4.50 is very critical and 4.51-5.00 is extremely critical (see Adewunmi, Omirin and Famuyiwa, 2011; Olanrewaju, Khamidi and Idrus, 2010). A systematic stratified sampling method was employed to select contracting firms from a list of registered contractors and consultants in professional recognized bodies. The client organizations were selected using a purposive sampling technique. A questionnaire survey was conducted among representatives from seventy-five major contracting/consulting firms and client organizations involved directly in maintenance projects in

Lagos, Nigeria. Sixty-three of the questionnaires were found valid for the study. The data collected was analysed using SPSS version 22.0.

The descriptive statistic of the responses was studied. A ranking of the factors based on the mean score of the responses through descriptive statistic was done. A test of one way Analysis of Variance (ANOVA) was done to study the difference in the perception of the criticality of these factors by the three groups of respondents, namely the clients, maintenance contractors, and the consultants. Factors with a less than 0.05 significance are said to have a different perception among the respondents. To identify which group of respondents had a different opinion, a Post Hoc (Tukey's B) test was conducted for the factors with a significance value less than 0.05. The test compares the means of the group of respondents. In addition, Cronbach's alpha was used in this study to test the internal consistency among the critical success factors of maintenance projects. Factor Analysis by Principal Component Analysis Method was done to extract the critical underlying factors (see Divakar and Subramanian, 2009, Ghanaee and Pourezzat, 2013, Tan et al., 2014).

4. Results

The demographic of the respondents (see Table 2) show that 47.6 percent of the respondents were forty years old and above while 74.8 percent had more than five years of practicing experience in the construction industry. Also, 25.4 percent, 44.4 percent, and 30.2 percent represent the participation of the client, contractor, and consultant organizations respectively.

The descriptive statistics identified fourteen factors overall with a mean score more than 2.50, depicts that the factors were critical to maintenance project success. In addition, the contractors identified sixteen critical factors while the clients and the consultants identified eleven and fourteen critical factors, respectively, as shown in Table 3. From the overall mean score of the factors, simplicity of programs, effective maintenance cost allocation budgeting, ease of techniques used, risk management in maintenance work and communication and information flow are the five most critical success factors (CSFs) for a maintenance project.

Table 2: Characteristics of respondents

Demographics of the respondents	Frequency	Percentage
Age of respondents		
30-39	33	52.40
40–59	28	44.40
60 and above	2	3.20
Professional qualification		
Council of Registered Builders of Nigeria (CORBON)	29	46.00
Architects Registration Council of Nigeria (ARCON)	7	11.10
Council of Registered Engineers of Nigeria (COREN)	11	17.50
Others	16	25.40
Gender		
Male	53	84.10
Female	10	15.90
Years of experience		
0–5	16	25.40
5–10	31	49.40
11–15	8	12.70
15 years and above	8	12.70
Educational qualification		
Bsc/B.Tech	20	31.70
MSc	12	19.00
HND	18	28.60
PGD	8	12.70
PhD	5	7.90
Business type		
Client organization	16	25.40
Contractor organization	28	44.40
Consultant organization	19	30.20

The level of significance (Sig.) of each factors was extracted from a one way ANOVA test as shown in Table 4, it indicated that four factors were significant as viewed by the respondents with a significance level $p< 0.05$. These factors were partnering (p=. 000), risk management in maintenance work (p=. 007), training of employees in maintenance-related works (p=. 015) and project program and scheduling (p=. 001). This means that the respondents had different perceptions of the factors as they affect their maintenance project's activities.

To study which group of the respondents perceived the factors differently, a Post Hoc (Tukey's B) test was conducted for the factors whose significance value was less than 0.05. As shown in Table 5, the maintenance contractors perceived partnering differently. The reason for this may be due to the challenges faced during business partnerships experienced in the study area. The problems of partnerships, such as trust and integrity between the partners, are major issues with which to contend, and these issues affect successful project deliveries. Further, the clients perceived risk management in maintenance work differently. This may be due to the fact that the clients are not directly involved in the execution stage of the maintenance project, whose nature is characterized by many uncertainties and risks.

Table 5 also indicates that the training of employees in maintenance-related work was perceived differently by the clients and maintenance contractors with an overlapping effect. The issue of training staff to achieve technical competence cannot be overemphasized, but the training of personnel is solely the responsibility of the company owners, which most contractors ignore due to the cost implication and the fact that long time benefits can't be predicted. However, the clients and the consultants may believe that trained and competent maintenance personnel will deliver a successful project. In relation to a project, program, and scheduling, the clients may perceive differently due to the fact that is not their responsibility to plan for the project; this is certainly the sole duty of the contractor.

Table 3: Ranks of factors that determine maintenance project success

Variables		Contractors		Consultants		Clients		Overall	
		Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
V1	Training of employees in maintenance-related work	2.87	9	2.88	8	2.65	7	2.80	8
V2	Ease of techniques used	3.15	3	2.40	17	3.30	1	2.95	3
V3	Simplicity of program	3.63	1	2.96	5	2.89	3	3.16	1
V4	Information and communication technology (ICT)	2.73	12	2.92	6	2.39	13	2.68	10
V5	Process coordination	2.07	17	2.92	6	2.83	4	2.61	13
V6	Early involvement of project team	2.93	7	2.76	10	2.30	15	2.66	11
V7	Experience and competent workforce	2.60	15	2.48	16	2.30	15	2.46	15
V8	Maintenance project planning and control	2.87	9	2.16	18	2.22	18	2.42	18
V9	Project program and scheduling	2.73	12	3.36	1	2.52	10	2.87	6
V10	Partnering	2.67	14	2.60	13	2.30	15	2.52	14
V11	Effective maintenance cost allocation budgeting	3.27	2	3.04	3	3.00	2	3.10	2
V12	Understanding the stakeholder's attitude	3.07	5	2.68	12	2.65	7	2.80	8
V13	Lean and just in time approaches	2.07	17	2.88	8	2.43	12	2.46	15
V14	Continued improvement	2.93	7	3.08	2	2.57	9	2.86	7
V15	Standardization	2.87	9	2.56	15	2.52	10	2.65	12
V16	Communication and information flow	3.13	4	2.72	11	2.83	4	2.89	5
V17	Risk management in maintenance work	3.00	6	3.04	3	2.78	6	2.94	4
V18	Working collaboration	2.53	16	2.40	17	2.35	14	2.43	17

Note: 1-1.50 (not critical) and 4.51-5.00 (extremely critical)

Table 4: Level of significance for maintenance project success factors

Factor No	Factor Name	Sig
V1	Training of employees in maintenance-related work	.007
V2	Ease of techniques used	.792
V3	Simplicity of program	.356
V4	Information and communication technology (ICT)	.738
V5	Process coordination	.128
V6	Early involvement of project team	.683
V7	Experience and competent workforce	.421
V8	Maintenance project planning and control	.203
V9	Project program and scheduling	.015
V10	Partnering	.000
V11	Effective maintenance cost allocation budgeting	.525
V12	Understanding the stakeholder's attitude	.334
V13	Lean and just in time approaches	.087
V14	Continued improvement	.902
V15	Standardization	.656
V16	Communication and information flow	.463
V17	Risk management in maintenance work	.001
V18	Working collaboration	.204

Table 5: Results of the Post Hoc (Tukey's B) test

Groups and Variables	Frequency	Output	
Factor Name	N	Subset for alpha=0. 05	
		1	2
Partnering			
Consultant	23	2.26	
Client	15	2.80	
Maintenance Contractor	25		3.76
Risk management in maintenance work			
Consultant	23	1.70	
Maintenance Contractor	25	2.36	
Client	15		3.13
Training of employees in maintenance-related work			
Consultant	23	2.26	
Client	15	3.00	3.00
Maintenance Contractor	25		3.44
Project program and scheduling			
Consultant	23	2.13	
Maintenance Contractor	25	2.44	
Client	15		3.27

4.1 *Reduction of number of variables*

According to Field (2005) and Ho (2006), factor analysis is used to reduce variables and identify clusters of interrelated variables. To reduce the factors that determine the maintenance success in this study, a Varimax with Kaiser Normalization was employed to generate the final values. To categorize factors into one component, 0.50 values were used as a benchmark. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy test value is 0.622, which indicates that the sample size was adequate for factor analysis. The coefficient alpha in this test is 0.801, showing an acceptable internal consistency for these factors. All eighteen success factors identified were subjected to factor analysis with Varimax Rotation with Kaiser Normalization Criterion (see Table 6).

Table 6: Variables loading

	Component					
Variables (Initial factors)	**1**	**2**	**3**	**4**	**5**	**6**
Training of employees in maintenance-related work (V1)	.084	.624	.287	-.005	-.245	-.097
Ease of techniques used (V2)	.161	.534	.213	.497	-.347	.047
Simplicity of program (V3)	.050	.760	.082	.110	-.011	.078
Information and communication technology (ICT) (V4)	.787	.117	-.016	.009	-.157	-.010
Process coordination (V5)	-.022	.019	.073	.111	-.098	.868
Early involvement of project team (V6)	.401	.068	.564	.368	-.085	-.163
Experience and competent workforce (V7)	.741	.089	.175	.080	.008	-.077
Maintenance project planning and control (V8)	.078	.448	.043	.657	.387	.175
Project program and scheduling (V9)	-.010	.251	.738	-.005	.065	.115
Partnering (V10)	.343	.631	-.234	-.214	.170	.025
Effective maintenance cost allocation budgeting (V11)	.348	-.231	.674	-.059	.037	.183
Understanding the stakeholder's attitude (V12)	.484	.137	.178	.201	-.655	.118
Lean and just in time approaches (V13)	.153	-.125	-.070	.767	-.192	.039
Continued improvement (V14)	.650	-.056	.230	.111	.097	.550
Standardization (V15)	.127	.462	.560	.126	.388	.106
Communication and information flow (V16)	.219	-.064	.369	-.070	.633	-.063
Risk management in maintenance work (V17)	-.070	.383	.536	-.272	.018	.510
Working collaboration (V18)	.617	.218	.105	.250	.240	.041

Note: Shaded cells denote common variables in each component.

From the results of the factor analysis, the maintenance project success factor variables were grouped into components. The underlying factors extracted were named as (1) Team integration and knowledge transfer, (2) Project learning and maintenance methodology, (3) Stakeholders early project assessment, (4) Planning and control, (5) Information and communication management within project stakeholders, and (6) Quality and risk control as presented in Table 7. Table 7 further shows the average score of the extracted factors with values greater than 2.50, which indicated that all the underlying factor groups were critical to maintenance project successful delivery.

Table 7: Factors categories

Factor	**Variables (Initial factors)**	**Mean Score**	**Classification**	**Major focus (Extracted factors)**
1	V4, V7, V14, V18	2.53	Critical	Team Integration and Knowledge Transfer
2	V1, V2, V3, V10	2.98	Critical	Project Learning and Maintenance Methodology
3	V6, V9, V11, V15,V17	2.57	Critical	Stakeholders Early Project Assessment
4	V8, V13	2.54	Critical	Planning and Control
5	V12, V16	2.62	Critical	Information and Communication Management within Project stakeholders
6	V5, V14, V17	2.58	Critical	Quality and Risk Control

4.2 *Discussion of findings*

This study adds to existing knowledge by providing insights into the critical success factors in building maintenance projects. The present study is the first to report the critical success factors from the perception of the client, contractor and consultancy involved in building maintenance projects in developing countries in construction-related literature. The results of the study show that simplicity of programs, effective maintenance cost allocation budgeting, ease of techniques used, risk management in maintenance work, communication and information flow, Project program and scheduling and continued improvement were the seven critical factors that affected the success of maintenance projects in Lagos, Nigeria (see Table 3). These findings are in accordance with several previous studies' results. For instance, the simplicity of the program and the ease of techniques adopted are seen as CSFs which is in line with the results of Ad Wahid and Corner (2009) and Al-Hammad and Assaf (1999). Furthermore, the findings of the recent study indicate that effective maintenance cost allocation and budgeting can facilitate project success. This outcome is in a similar view with Tucker, et al. (2014), that value for money must be attain in project transactions. Also, Saqid et al. (2008) and Straub (2011) attests that cash flow, and the knowledge and competences in calculations of costs in project implementation are required. The ease of techniques adopted in the execution of the project is crucial to successful achievement as shown; this is in accordance to the technical competence found in Al Hammad and Assaf study. Risk management in maintenance works entails the safety measures put into place during the pre contract and contract planning stages. These safety issues are also identified in the study of Al Hammad and Assaf (1996) and Edmond et al. (2010).

Njuangang, Liyanage, and Akintoye, (2015) and Straub (2011) believe that effective collaboration and communication is needful for maintenance project success. This relates to the issue of partnership and early involvement of all the team in the project as shown in the current study. In addition, information and communication technology usage is considered vital for project success, Njuangang et al. (2015) support this when they reiterate that liaison and communication with ICT is a key performance factor. In addition, Ali et al. (2006), confirm that knowledge sharing and quality information among stakeholder's advance positive project achievements. Project programming and scheduling is also a critical success factor that determines the performance of maintenance projects in a developing country. According to Al-Hammad and Assaf (1996), Al-Zahrani (2001) and Divalcar and Subramanian (2009) project planning and scheduling are vital project CSF. The ability of the maintenance contractor's to plan and schedule the maintenance project to be executed is paramount for performance enhancement. Inclusively, maintenance project success cannot be achieved without continuous improvement within the organisation and during contract execution. Tellingly, it was reiterated by Tucker et al. (2014) and Wahid and Corner (2009) that continuous improvement in an ingredient to a successful project delivery.

The influence of stakeholder behaviour on project success cannot be overestimated. Understanding of stakeholders or customer altitude is confirmed in the findings of Turker et al. (2014); attest that stakeholder opinion is paramount to achieve maintenance project success. Added to this fact, Njuangang et al. (2015) ascertain that customers' satisfaction as not being the prime focus of CSF as it suppose to be; which is also supported in Tan et al. (2014). Furthermore, trained, skilful and competent employee's also contributes to project success as indicated in the study, which is in accordance with the findings in Njuangang et al. (2015), Straub (2011) and Al-Hammad and Assaf (1999).

Four success factors were also perceived to be significant to the successful delivery of a maintenance project (in Table 4); these were partnering, risk management in maintenance work, training of employees in maintenance-related work, and project program and scheduling. These findings agree with the results of, such as Njuangang et al. (2015), Tan et al. (2014), Bamber, Sharp, and Hides (1999); and Al-Hammad and Assaf (1996). The effective integration of these four factors will enhance the continuous improvement in the maintenance organization performance.

In view of the extracted factors in Table 7, the CSFs are grouped under six major components as team integration and knowledge transfer; project learning and maintenance methodology; stakeholders early project assessment; planning and control, information and communication management within project stakeholders and quality and risk control. Project learning and maintenance methodology will go a long way to determine a successful maintenance project delivery. The lessons learnt and the methods employed from previous projects must be put into play as a preventative measure in any new project environment. This will reduce the effect of encountering similar challenges and mistakes made. Further, the understanding of the maintenance processes and procedures will assist the project stakeholders to effectively and efficiently manage the maintenance project activities. Also, the ability to manage information and communication flow within the project stakeholders is paramount to maintain a cordial relationship among the project participants and the smooth running of the project execution. In addition, team integration and knowledge transfer induced technical competence and reliability within the project stakeholders; it also facilitates project learning pathways. Effective planning and control is necessary to attain quality and reduce the risks involved in the maintenance project delivery. This can be achieved by an early assessment of the project by the stakeholders through a viability and feasibility study of the project. The consideration and implementation of all these success factors for a maintenance project identified in the study will improve the maintenance project cycle. According to Edmond, Lam Albert, and Chan Daniel (2010), "project success is an abstract concept, the identification of key performance indicators enables project performance to be improved and the quantification of the perceptions towards success even sets a benchmark for construction excellence".

5. Conclusion

The management aspects are vital to the successful completion of a maintenance project. The early involvement of all stakeholders is paramount in this regard. The critical factors identified from the results of the study should be effectively monitored by the project team and the maintenance contractor project manager. The maintenance contractor team should liaise with the client and the consultant organization. This team integration and collaboration acts as a partnership in executing maintenance project and will facilitate a successful completion of such project. However, the results of the study may not be generalized to all project environments. The study recommends that the implementation of these factors will improve building maintenance project outcomes. Also, there is a need for further study to explore the relationship between critical success factors and maintenance project outcome in developing countries.

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A Bespoke Approach for Relating Material Waste to Cost Overrun in the Construction Industry

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Abstract

The problems of material waste and cost overruns are common in the construction industry. These problems occur at different stages of a construction project, from planning, design to project execution. The argument on how to eliminate cost overruns has been on-going for the past 70 years as on-site wastage of materials leads to increase in the final project cost. This paper examines the relationship between the causes of material waste and those of cost overrun at the pre-contract and post-contract stages of a project. Literature review revealed that all (100%) the causative factors for material waste at the pre-contract and post-contract stages of a project are linked to 96.88% and 81.36% of the causes of cost overruns at these stages respectively. The results were further validated by interviews conducted with 30 construction professionals using purposive sampling method within Abuja, Nigeria. Other causes of cost overruns which are not related to those of material waste are mostly the micro-economic and macro-economic factors. It was also found that to achieve Effective Construction Material Waste Management (ECMWM) for any construction project, the causes of material waste must be controlled at its sources and causes, and at different stages of a project. The implication of these findings is that project cost overrun can be effectively controlled by curbing the causes of material waste.

Keywords: Construction industry; Cost overruns; Construction waste; Material waste.

1. Introduction

The construction industry remained one of the driving forces behind the socio-economic development of any nation. However, it is faced with severe problems of cost overruns and construction waste (Abdul-Rahman et al., 2013; Osmani et al., 2008; Nagapan et al., 2012a; Saidu and Shakantu, 2016a). Material wastage has become a serious problem, which requires urgent attention in the construction industry (Adewuyi and Otali, 2013). The majority of this waste has not been well managed, thus causing substantial health and environmental problems (Imam et al., 2008), and affecting the performance of many projects (Adewuyi and Otali, 2013; Ameh and Itodo, 2013; Oladiran, 2009; Saidu and Shakantu, 2016b). This problem is disclosed by various authors reporting on the situation, for instance, 28.34% of the total waste sent to landfills in Malaysia originates from construction activities (Begum et al., 2007); the US generates 164million tonne of construction waste annually representing 30-40% of the country's Municipal Solid Waste (MSW) (Osmani, 2011); China alone generates 30% of the world's MSW, out of which construction and demolition waste represents 40% of the country's MSW (Lu and Yuan, 2010); 10% of the materials delivered to sites in the United Kingdom (UK) construction industry end up as waste that may not be accounted for (Osmani, 2011); and Ameh and Itodo (2013) noted that for every 100 houses built, there is sufficient waste materials to build another 10 houses in Nigeria.

Similarly, cost overrun is a common problem in both developed and developing countries (Memon et al., 2013).

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For instance, 33.3% of construction project owners in the UK are faced with the problems of cost overrun (Abdul-Rahman et al., 2013). Cost overrun is associated with projects across twenty nations and five continents of the world (Allahaim and Liu, 2012; Flyvbjerg et al., 2004). The argument on how to reduce or totally remove cost overruns from projects has been on-going among major stakeholders in the construction industry for the past seventy years (Apolot et al., 2010; Allahaim and Liu, 2012), but there is neither substantial improvement nor significant solution in mitigating its detrimental effects (Allahaim and Liu, 2012); and it is logical to reason that on-site wastage of material leads to increase in the final cost of a building project because, as materials are wasted, more will be required, thereby affecting the estimated cost of the project (Ameh and Itodo, 2013). This is regardless of the 5% contingency allowance to cover material wastage in the bills of quantities in countries like Nigeria. Therefore, the problems of material waste and cost overrun are occasioned by several causes at different stages of projects. These include: the planning stage, estimating stage, design and design management stage, as well as the construction stage. Identification of these causes at different stages and the application of relevant control measures to minimise their occurrence is a step towards alleviating the consequences (Mou, 2008; Oladiran, 2009; Nagapan et al., 2012b; Saidu and Shakantu, 2015). Ameh and Itodo (2013) assert that most managers of construction projects pay little attention to the effects of material waste generated on cost overrun. Many studies have been conducted in this field, for instance, Tam et al. (2007) assessed the levels of material wastage affected by sub-contracting relationships and projects types with their correlations on construction site; Ameh and Itodo (2013) assessed professionals' views of material wastage on construction sites and cost overruns. The study adopted a survey (questionnaire) research approach which is considered a subjective assessment. Saidu and Shakantu (2015) examined the relationship between quality of estimating, construction material waste generation and cost overruns in Abuja, Nigeria; Saidu and Shakantu (2016a) examined the relationship between material waste and cost overrun in the construction industry using literature based methodology and recommended further empirical investigations. Moreover, Saidu and Shakantu (2016b) developed a framework and an equation for managing construction-material waste and cost overruns but these are not empirically inclined. These therefore, provides the need for a research that provides a holistic assessment of the relationship between the causes of material waste and those of cost overrun at pre-contract and post-contract stage of a construction project. Hence, this paper examines the relationship between the causes of material waste and those of cost overruns with a view to suggesting the possible ways of minimising their effects at the pre-contract and the post-contract stage of a project. To achieve this, the following objectives were formulated: To identify the material waste causes that have effects on cost overruns at pre-contract and post-contract stages of a project; and to determine material waste control measures that have effects in controlling cost overruns at the pre-contract and at the post contract stages of a project.

2. Literature Review

2.1 Construction Waste

Construction waste is a global challenge faced by construction practitioners. It can have a significant impact on time, cost, quality and sustainability (Saidu, 2016).

Construction waste is generally classified into two, namely: the physical waste (the waste that could be physically seen and touched) and the non-physical waste (Nagapan et al., 2012b).

2.1.1 Physical Construction Waste

Physical construction waste is the waste from construction and renovation activities, including building and civil engineering works. It is however, referred by some directly as solid waste: the inert waste, which comprises mainly sand, bricks, blocks, steel, concrete debris, tiles, bamboo, plastics, glass, wood, paper, and other organic materials (Nagapan et al., 2012b; Ma, 2011; Saidu and Shakantu, 2016a). This type of waste could either be recovered through recycling or re-use of some of its constituents; or completely lost due to the fact that they may be irreparably damaged or simply stolen. The wastage is usually removed from the site to landfills (Nagapan et al., 2012b; Saidu and Shakantu, 2015; Saidu, 2016).

2.1.2 Non-Physical Construction Waste

The non-physical waste normally occurs during the construction process. In contrast to the physical or material waste, non-physical waste relates to time overruns and cost overruns for construction projects (Nagapan et al., 2012b; Saidu, 2016). Similarly, Ma (2011) defines waste as not only associated with wastage of materials, but also to other activities such as delays due to repair, waiting time, among others. Besides that, waste can be considered as any inefficiency that results in the use of equipment, materials, labour, and money in the construction process (Ma, 2011). In other words, waste in construction is not only focused on the quantity of materials wasted on site, but also covers issues like overproduction, waiting time, material handling, inventories, and unnecessary movement of workers (Nagapan et al., 2012a).

2.2 Construction Cost Overrun

Cost overruns are part of the non-physical waste that have plagued construction projects for decades or even centuries (Edward, 2009). Cost overrun is also known as "cost increase" or "budget overrun"; and it involves unanticipated costs incurred in excess of the budgeted amounts (Shanmugapriya and Subramanian, 2013). It has also been referred to as the percentage of actual or final costs above the estimated or tender costs of the project (Ubani et al., 2011; Jenpanistub, 2011). Azhar et al. (2008) view cost overrun simply as an occurrence, where the final or actual cost of a project surpasses the original or initial estimates. It is the actual or final costs, minus the estimated cost, divided by the estimated/tender costs of a project expressed as a percentage (Memon, 2013; Ubani et al., 2011) This is represented mathematically:

$$Cost\ Overrun = \frac{Actual\ Cost - Estimated\ Cost}{Estimated\ Cost} X\ 100 \qquad (1)$$

The actual costs are referred to as the real and accounted construction costs realised at the completion of a project; while the estimated costs are the budgeted, estimated or forecasted construction costs determined at the inception of projects after the actual design has been developed (Ubani et al., 2011; Memon, 2013). Nega (2008) defines cost overrun as an occurrence, in which the delivery of contracted goods/services is claimed to require more financial resources than was originally agreed upon between a project sponsor and a contractor.

2.3 Causes of Cost Overruns

Cost overruns in the construction industry have been attributed to a number of causes, including technical errors in design or estimation, managerial incompetence, risks and uncertainties, suspicions of foul play, deception and delusion, and even corruption (Ahiaga-Dagbui and Smoth, 2014). The two main causes of cost overruns in a project, according to Flyvbjerg, Holm and Buhl (2004) are: optimism bias and strategic misrepresentations. Optimism bias summarises the systematic tendency of decision-makers to be more positive about the results of planned actions; whereas strategic misrepresentations have to do with confusing or misleading actions used by planners in politics and economics, to ensure that projects proceed. Furthermore, other surveys have identified the four major factors that cause cost overruns for a project are: variations in design, insufficient project planning, inclement weather conditions, and building materials' price fluctuation (Allahaim and Liu 2012).

In another study, the top five (5) important causes of cost overruns in large projects in Vietnam were: poor site management and supervision, poor subcontractors and project management assistants, owners' financial constraints, contractors' financial difficulties, and changes in design (Le-Hoai et el., 2008).

Al-Najjar (2008) investigated the causes of cost overruns in the Gaza strip, and found that fluctuations in the prices of construction materials, as a result of border closure, was the major cause of cost overruns. Other factors were: delays in the delivery of materials and equipment to site, and inflation of the prices of materials. In another study, Subramani et el. (2014) surveyed the causes of cost overruns in India. The results indicated that, slow decision-making at the planning stage of a project, poor project schedules and management, increases in the prices of materials and machines, poor contract management, poor design, delay in producing design, rework due to mistakes, land-acquisition problems, poor estimation or estimation techniques, and the long-time taken between the design and the time of bidding/tendering are the major causes of cost overruns.

Aziz (2013) examined the factors causing cost overruns in waste-water projects in Egypt, and concluded that lowest tendering procurement method, additional works, bureaucracy in tendering methods, wrong cost-estimation methods, and funding problems by client were the major causes of cost overruns.

Shanmugapriya and Subramanian (2013) identified 54 causes of cost overruns and categorised them in to six (6) major groups, namely: financial group (the fluctuating exchange rate, and the lack of sound financial management and planning); construction items group (mistakes during construction, wastages on-site, inadequate design, the lack of co-ordination at design stage, and the rework needed due to mistakes or errors); political group (difficulties in importing equipment and materials); materials group (changes in materials specifications, material price increases, and material shortage); labour and equipment group (the high cost of machinery, high maintenance costs of machinery, frequent breakdown of the construction plant and equipment, and high transportation costs); and owner's responsibility group (additional work by clients, and the high quality of work required).

Ameh et al. (2010) examined the significant factors causing cost overruns in the telecommunication projects in Nigeria. The results revealed the following: lack of experience by the contractor, the high cost of importing materials, and the materials' price fluctuation. In another study, Ejaz et al. (2011) discovered that increases in material prices, poor project control techniques, shortage of technical personnel, delays in work approval, and the shortage of materials and plant/equipment are the major causes of cost overruns in Pakistan.

Baloyi and Bekker (2011) conducted a study on the causes of cost overruns in the 2010 FIFA world cup stadia in South Africa. The result revealed that project complexity, increases in labour costs, inaccurate quantity estimations, differences between the selected bid and the consultants' estimates, variation orders by clients during construction, and manpower shortage were the main causes of cost overruns.

Kaliba et al. (2009) concluded that the problem of cost overruns in Zambia were caused by inclement weather conditions, changes in the size of projects, the cost of environmental sustainability, delays in the work programme, civil unrest, technical constraints, and increases in material prices.

Omoregie and Radford (2006) examined the causes of cost overruns in the infrastructural projects in Nigeria. The result revealed the major causes as: fluctuations in material prices, financing and payments made for completed works, inefficient contract management, delays in scheduling, variations in site condition, inaccurate cost estimates, and material shortages. In another study, Kasimu (2012) found that fluctuations in materials prices, insufficient time, lack of experience in contracts works, and incomplete drawings were the major causes of cost overruns in building construction projects in Nigeria.

Malumfashi and Shuaibu (2012) conducted a study on the causes of cost overruns in the infrastructural projects in Nigeria. The results revealed the major causes as improper planning, material-price fluctuations, and inadequate finance from the project's inception.

2.4 Construction-Material Waste and Cost Overrun

Construction waste entails both the physical and the non-physical waste, therefore, there is a nexus between material waste originating from the physical waste and cost overrun from the non-physical waste, since they both originate from the same waste family (Saidu and Shakantu, 2016a). This classification is shown in Figure 1

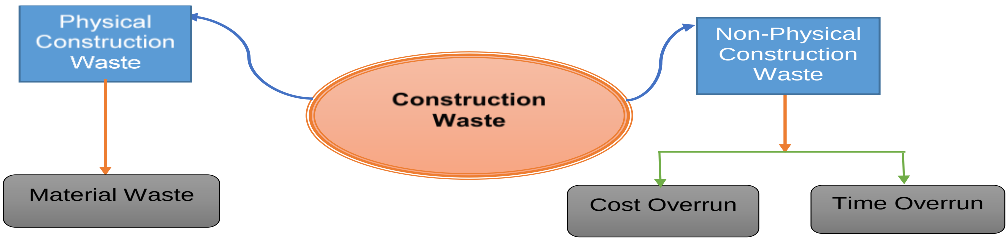

Figure 1: Classification of Construction Waste

Moreover, research evidence revealed that material waste accounts for additional percentage of cost overrun in countries like the UK, Hong Kong, Netherlands, Nigeria and so forth (Ameh and Itodo, 2013; Saidu and Shakantu, 2015; Saidu and Shakantu, 2016a; Saidu, 2016). For instance, Tam et al. (2007 in Ameh and Itodo, 2013) reported that, in the UK, material waste accounts for an additional 15% of construction project cost overruns and for approximately 11% of construction cost overruns in Hong Kong. Similarly, a study conducted in the Netherlands revealed a cost overrun of between 20% and 30% as a result of construction-material wastage (Bossink and Bounwers, 1996). However, the methodologies adopted to achieve these contributions of material waste to cost overruns are based on surveys and considered a subjective assessment. Nonetheless, these studies have failed to objectively (quantitatively and empirically) address the contributions of material waste to project cost overruns, because of wrong perceptions and this calls for actual data such as on-site observation and records (Saidu and Shakantu, 2016b). It was on this basis that Saidu and Shakantu (2016b) carried out an objective assessment of the contributions of material waste to cost overruns in Abuja, Nigeria. The results revealed that material waste contributes an average of 4.0% to project cost overruns for the entire projects.

3. Research Methodology

This research covers building construction projects within Abuja, the Federal Capital Territory of Nigeria. Abuja was selected because it is one of the metropolitan cities of Nigeria that has the highest population of professionals within the built environment and has many on-going construction projects. Primary data were generated from interviews conducted with thirty (30) construction professionals within Abuja. The interviews were conducted using purposive sampling techniques. It is purposive, because only building-construction professionals handling projects worth 1.6 billion Naira (8 million USD) and above were consulted/interviewed. Projects of 8 million USD and above are likely to be handled by more experienced professionals, who might be more familiar with the issues leading to material waste and cost overrun than the projects of less value. Furthermore, Leedy and Ormrod (2014) believed that the size of interviews using a purposive sampling technique ranges between 5 and 25 participants. The thirty (30) professionals interviewed in this research included: 15 Project Managers (PMs), 9 Quantity Surveyors (QSs), 5 Site Engineers (SEs), and 1 Senior Technical Officer (STO) of a construction-waste management department. The interviews were on the issues relating to material waste and cost overruns at the pre-contract and at the post-contract stages of a construction project.

An interview guide was used to collect empirical data. The interviews were conducted in order to solicit the opinions of construction professionals on the causes of material waste that relate to causes of cost overruns. The semi-structured but in depth interview guide assisted the researchers. The interview guide was structured in two major group namely: pre-contract and post-contract stages of a project. Probing questions were asked during discussion with the interviewees in order to obtain further information. An average of thirty-five (35) minutes was spent in conducting each interview.

All the thirty (30) respondents identified in this research through the purposive sampling method responded to all the questions presented for discussion. Moreover, the application of the inductive analysis of data in qualitative research enabled the researchers to extensively condense raw data into brief and summary format, and to establish clear links between the research purpose and the summary findings derived from raw data. The recorded, transcribed and interpreted interview data were analysed by using the deductive approach, which involves constant comparative analysis of the data, after it has been sorted and coded to generate knowledge about any common pattern within the interviewees' evidence on material waste and cost overrun. The analysis began by comparing the opinions made by the first two interviewees. The process continued with a comparison of the data from the comments and inputs from each new interviewee, until all the responses had been compared with each other. The similarities and differences among the interviewees' responses were used to develop a conceptualisation of the possible relationship between the various data items.

The interviews result which are composed in themes are therefore, summarised in Table 3 and Table 4 of this research.

4. Research Findings

4.1 Findings from Secondary Data (Literature Review)

This section presents the research results identified from the literature review.

4.1.1 Relationship between Material Waste and Cost Overrun at Pre-Contract Stage of a Project

Table 1 reveals that most of the causes of material waste and those of cost overruns identified from the literature are the same. All the causes of material waste were also identified as the causes of cost overrun at the pre-contact stage of a project but not vice versa. For instance, 31 out of the 32 causes of cost overruns considered at the pre-contract stage of a project were also found to cause material waste, which indicate a 96.88% relationship (pre-contract stage). The only cause of material waste not linked to cause of cost overrun was 'the practice of assigning the contract to the lowest bidder'. This means that all causes of material waste also cause anticipated cost overrun at the pre-contract stage of a project. But only 96.88% of the causes of cost overrun cause material waste. The remaining 3.12% is not related. This implies that, managing the causes of material waste at this stage denotes managing a 96.88% of the causes of cost overruns.

4.1.2 Relationship between Material Waste and Cost Overrun at Post-Contract Stage of a Project

Table 2 shows the causes of cost overrun that are related to the causes of material waste at the post-contract stage of a project. Out of the 66 causes of cost overruns considered, 54 also cause material waste showing an 81.81% relationship at the post-contract stage of a project. This shows that, at the post-contract stage of a project, all material waste causes are also responsible for the causes of cost overruns. But on the other hand, when causes of cost overruns are considered, there is an 81.81% relationship with causes of material waste. The remaining 18.19% are not related and are mostly, the micro and macro-economic factors. This implies that managing material waste at this stage denotes managing 81.81% of cost overruns.

The material waste causes that are marked with the sign (X) are not found in the causes of cost overrun and therefore, labelled as not related to cost overrun.

Table 1. Causes of material waste related to causes of cost overruns at the pre-contract stage.

Sn	Causes of Cost overrun	Cost overrun	Material waste
1	Design error	✓	✓
2	Deficiencies in cost estimates	✓	✓
3	Insufficient time for estimate	✓	✓
4	Improper planning at on stage	✓	✓
5	Political complexities	✓	✓
6	Insurance problems	✓	✓
7	Changes in material specification	✓	✓
8	Laws and regulatory framework	✓	✓
9	Lack of experience of local regulation	✓	✓
10	Practice of assigning contract to the lowest bidder	✓	x
11	Poor communication flow among design team	✓	✓
12	Communication error amongst parties in planning	✓	✓
13	Poor knowledge of the changing requirements	✓	✓
14	Lack of design information	✓	✓
15	Designing irregular shapes and forms	✓	✓
16	Different methods used in estimation	✓	✓
17	Improper coordination	✓	✓
18	Delays in design	✓	✓
19	Optimism bias	✓	✓
20	Complicated design	✓	✓
21	Inadequate specifications	✓	✓
22	Incomplete drawings	✓	✓
23	Error in design and detailing	✓	✓
24	Poor design management	✓	✓
25	Inadequate site investigation	✓	✓
26	Difficulties in interpreting specification	✓	✓
27	Delay in preparation and approval of drawings	✓	✓
28	Designing uneconomical shapes and outlines	✓	✓
29	Frequent demand for design changes	✓	✓
30	Inexperienced designer	✓	✓
31	Unsatisfactory budget for waste management	✓	✓
32	Lack of communication among parties at pre-contract stage	✓	✓
Summary=31/32X100=96.88%			

Table 2. Causes of material waste related to causes of cost overrun from literature

Sn	Causes of Cost overrun (post-contract)	Cost overrun	Material waste
1	Monthly payment difficulties	✓	x
2	Poor planning by contractors	✓	✓
	Discovery of heritage materials to replace imported ones	✓	✓
4	Market conditions	✓	x
5	Cash flow and financial difficulties faced by contractors	✓	x
6	Slow information flow between the parties	✓	✓
7	Escalation of material prices	✓	x
8	Increase in wages	✓	x
9	Poor site management and supervision	✓	✓
10	Exchange rate fluctuation	✓	x
11	Deficiencies in the social structure	✓	✓
12	Optimism bias	✓	✓
13	Labour cost increases due to environment restriction	✓	**x**
14	Insufficient equipment	✓	✓
15	Deficiencies in the infrastructure	✓	✓
16	Lack of communication among parties	✓	✓
17	Change in the scope of work	✓	✓
18	Delay of payment to supplier/subcontractors	✓	✓
19	Shortage of materials	✓	✓
20	On-site waste	✓	✓
21	Project size	✓	✓
22	Lack of constructability	✓	✓
23	Unrealistic contract duration	✓	✓
24	Delay in material procurement	✓	✓
25	Inexperienced contractor	✓	✓
26	Shortage of site workers	✓	✓
27	Work security problems	✓	✓
28	Re-work	✓	✓
29	Experience in contracts	✓	✓
30	Workers health problems	✓	✓
31	Unexpected subsoil conditions	✓	✓
32	Poor geological surveys	✓	✓
33	Financial difficulties of contractor	✓	✓
34	Social and cultural impact	✓	✓
35	Inaccurate site investigation	✓	✓
36	Inadequate use of modern equipment & technology	✓	✓
37	Obtaining materials at official current prices	✓	x
38	Labour problems	✓	✓
39	Increase in material prices	✓	x
40	Owner interference	✓	✓
41	Slow payment of works	✓	x
42	High interest rate charged by banks on loans	✓	x
43	Fraudulent practices	✓	✓
44	Labour disputes and strike	✓	✓
45	Improper coordination amongst parties at post contract stage	✓	✓
46	Poor technical performance	✓	✓
47	Equipment availability/failure	✓	✓
48	Number of works being done at same time	✓	✓
49	Poor financial control on site	✓	✓
50	Poor site management and supervision	✓	✓
51	Site constraints	✓	✓
52	Lack of skilled labour	✓	✓
53	Mistakes during construction	✓	✓
54	Delay in decision making	✓	✓
55	Late materials/equipment delivery	✓	✓
56	Unpredictable weather condition	✓	✓
57	Unforeseen site conditions	✓	✓
58	Management-labour relationship	✓	✓
59	Inexperience of project location	✓	✓
Summary=48/59X100=81.36%			

4.1.3 Summary of the Relationships at the Pre-Contract and Post-Contract Stages of a Project

Summing all the causes at both the pre-contract and the post-contract stages, 32+59=91, a total of 79 out of 98 causes of cost overruns also cause material waste showing 79/91X100=86.81% relationship. These findings are also graphically represented in Figure 2

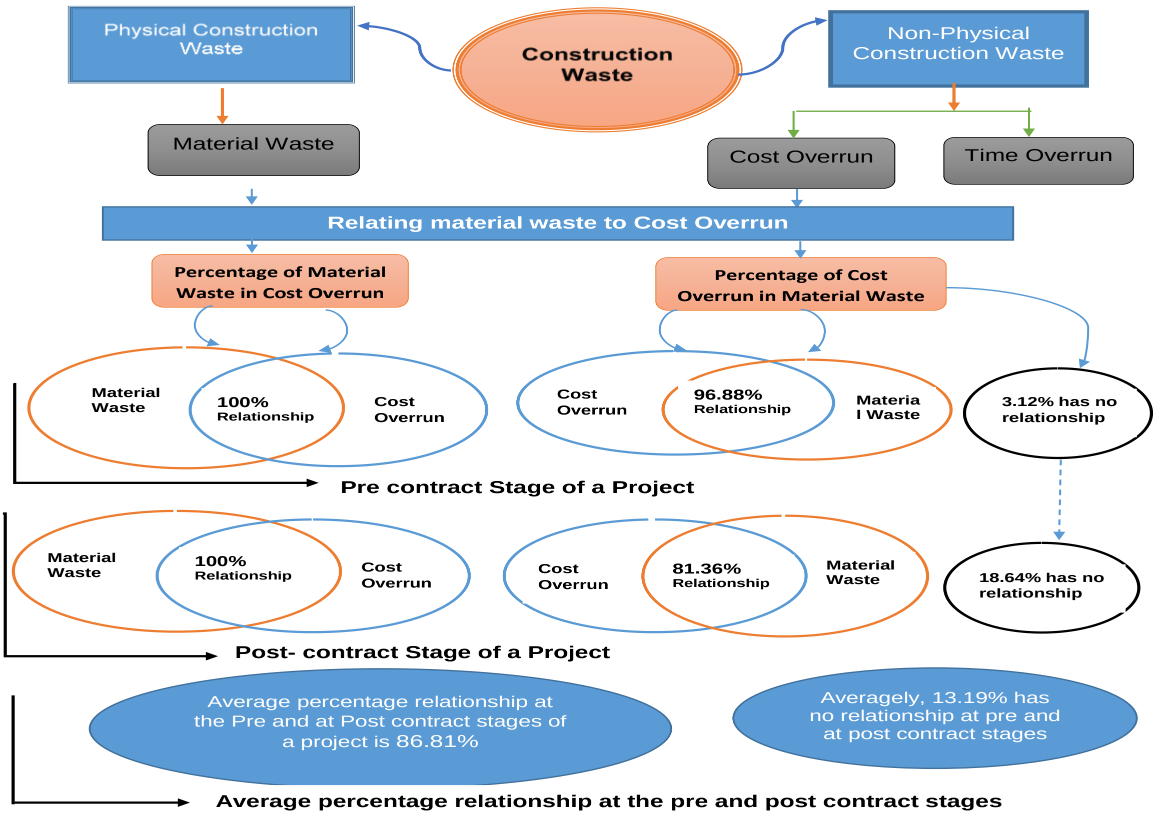

Figure 2. Relationship between material waste and cost overrun at all stages of a project

It can therefore be concluded that the relationship between causes of material-waste and causes of cost overruns is 86.81%. Though, this result is not the actual contribution of material waste to cost overrun, but a relationship between their causes (material waste and cost overruns). The actual contribution of material waste to cost overrun could vary from site to site and from different geographical locations.

4.2 Findings from Primary Data (Interview)

This section presents the research findings identified from interview session with the respondent.

4.2.1 Material Waste Causes Related to Causes of Cost Overruns at the Pre-Contract and Post Contract Stages of a Project

Table 3 summarises the results of the interviews conducted with construction professionals on the causes of material waste that are related to the causes of cost overruns at pre-contract and pot-contract stages of a project.

Sn	Material waste causes that relate to causes of cost overruns at the pre-contract stage of a project	Sn	Material waste causes that relate to causes of cost overruns at the post-contract stage of a project
	Planning phase		***Site management phase***
			Storage source
1	Improper planning	1	Wrong material/equipment storage/stacking
2	Lack of feasibility and viability studies	2	Wrong materials handling from storage to application
3	Lack of legislative enforcement		
4	Inadequate site investigation	3	Damage by other trades
5	Inadequate scheduling	4	Poor site storage area
6	Poor communication flow among members	5	Long storage distance from application point
7	Improper coordination of the entire project	6	Damage by weather
8	Unsatisfactory budget for waste management		***Security source***
9	Insurance problem	7	Inadequate site security/Fencing
10	Poor plan for material standardization	8	Theft
11	Inadequate plan for waste management unit	9	Vandalism, sabotage pilferage, and material damage
12	Improper plan for material waste re-use & disposal	10	Power and lighting problems on site

13	Improper program of work
14	Improper plan for site organization and layout
15	Lack of regular site meetings
16	Compliance with local authority in case of local laws
17	Improper planning and understanding of method statement
18	Improper planning of project risks
19	Lack of inclusion of waste management in bidding process
20	Improper plan for the establishment of a quality control unit
21	Inexperienced personnel in planning
22	Improper plan for record of material inventory
23	Poor harmonization of brief
24	Poor knowledge of site conditions
25	Cost related problems
26	Inadequate identification of construction techniques
27	Poor material estimation
28	Communication error between client and designer
29	Frequent demand for design change
	Design phase
30	Frequent design changes and material specification
31	Error in design and detailing
32	Lack of design information
33	Design complexity / complication
34	Poor communication flow among design team
35	Designing dead spaces
36	Poor knowledge of the changing design requirements
37	Poor management of design process
38	Inexperience designer / design team
39	Interaction between various specialists
40	Designing uneconomical shapes and outlines
41	Lack of standardization in design/ sizes and units
42	Lack of buildability analysis
43	Difficulty in interpreting material specifications
44	Readability, constructability and maintainability
45	Insufficient time for design
46	Poor harmonization of client's brief
47	Over or under designing
48	Poor structural arrangement of a design
49	Aesthetic considerations
50	Poor planning of design process
51	Poor design functionality
52	Designing unavailable technology
53	Lack of geo-physical survey
	Estimating phase
54	Over/under estimating
55	Inaccurate quantity take-off
56	Insufficient time for estimate
57	Different estimation methods
58	Inexperienced estimator
59	Lack of detailed drawing and specifications (readable and interpretable)

	Site conditions
11	Lack of adherence to program of work
12	Leftover materials on site
13	Waste resulting from packaging
14	Lack of environmental awareness
15	Difficulties in accessing construction site
16	Problems relating to on-site health and safety
17	Wrong placement of equipment on site
18	Site accidents
19	Late delivery of materials
	Operation source
20	Lack of quality control
21	Lack of waste management plans
22	Non-availability of appropriate equipment
23	Wrong placement of equipment on site
24	Communication problems
25	Late information flow among parties
26	Lack of co-ordination among parties
27	Poor construction planning and control
28	Poor site supervision
29	Rework
30	Inappropriate records of materials
31	Lack/poor adherence to material waste regulations
32	Inappropriate delegation of responsibilities
33	Lack of experience
34	Site accidents
	Material procurement and transportation phase
35	Mistakes in material procurement
36	Procuring items not in compliance with specification
37	Errors in shipping
38	Mistakes in quantity surveys: Poor estimate for procurement
39	Wrong material delivery procedures
40	Delivery of substandard materials
41	Damage of material during transportation
42	Inadequate delivery schedule
43	Poor market conditions
44	Poor material handling
45	Waiting for replacement
46	Poor protection of materials and damage during transportation
47	Over allowance
48	Frequent variation orders
49	Poor product knowledge
50	Procuring wrong quantity of materials at the wrong time
51	Inexperienced personnel in estimation and procurement
52	Procuring substandard materials
53	Difficulties of vehicles in accessing site
54	Lack of quality control assurance for evaluation of procured product
55	Lack of professionalism and transparency in procurement

60	Inadequate project risks evaluation, analysis, and estimation	56	Competent procurement management
61	Inadequate knowledge of site conditions		
62	Lack of estimating information		
63	Poor knowledge of fluctuating market conditions/prices		
64	Frequent design change		
65	Late engagement of estimators		

4.2.1 Managing Material Waste and Cost Overrun

In order to effectively manage material waste and cost overruns on construction sites, the material waste control measures that have effects in controlling cost overruns at both pre-contract and post-contract stages of a project must be put in place. The material waste control measures that have effects on cost overruns were identified and summarised from the interview session with the respondents. These are presented in Table 4.

Table 4. Material waste control measures that have effects in controlling cost overruns at the pre-contract and at the post contract stages of a project

Sn	Material waste control measures that have effects in controlling cost overruns at the pre-contract stage of a project	Sn	Material waste control measures that have effects in controlling cost overruns at the post-contract stage of a project
1	Plan for early sub-soil investigations	1	Better transportation of materials
2	Plan for inclusion of waste management in bidding and tendering processes	2	Efficient methods of unloading materials supplied in loose form
3	Proper planning of construction projects layout	3	Adopting good materials abstracting
4	Proper investment into waste reduction	4	Provision of easy access road for vehicles delivery
5	Proper coordination and communication at pre-contract stage of a project	5	Adoption of unified method of estimating for procurement process
6	Improved planning and scheduling	6	Ordering appropriate materials quantity and timely delivery of materials
7	Execute a plan that will reduce frequent design change	7	Tight security, workable security lighting, and adequate site temporary fencing
8	Enhance regulation execution of related government departments and legislative enforcement	8	Integration of waste management into the assessment of construction contractor
9	Set a target for material waste reduction	9	Procuring in accordance with specification
10	Ensure adequate geophysical surveys	10	Experienced personnel in estimation and procurement
11	Proper insurance of works	11	Insurance of the procured materials
12	Plan for material standardisation	12	Recycle generated waste materials
13	Re-improving process (monitoring / learning from previous mistakes and improving on them)	13	Formation of a quality control unit for evaluation of procured product
14	Regular site meetings	14	Competent procurement management
15	Establishment of good waste management unit	15	Professionalism and transparency in procurement
16	Carrying design team along	16	Materials manufactured in standard units
17	Adequate material waste estimation	17	Knowledge of product to be manufactured
18	Planning of project risks	18	Better and improved supply chain management
19	Communication and coordination of design process	19	Adequate site organization and discipline
20	Consideration of available technology, resources and materials	20	Proper administration of 5Ms (men, material, money, machines and management) on site
21	Identification of construction technique	21	Proper scheduling and planning
22	Performance of feasibility and Viability studies	22	Use of skilled and experienced labour
23	Performing a buildability analysis	23	Adequate site control and supervision
24	Proper harmonization of brief	24	Competent supplier
25	Improve major project stakeholders' awareness on resource saving & environmental protection	25	Research and development in the discipline of waste management
26	A design recommending available human resources and local materials	26	Proper records and documentation of materials/daily record taking and materials request booklets.
27	Design for materials optimization	27	Improve contractors' onsite construction management

28	Design for reuse and recovery	28	Appropriate material storage
29	Design for offsite construction	29	Proper communication & coordination on site
30	Designing for deconstruction	30	Error-free construction process
31	Designing economic shapes and outlines	31	Process improvement techniques
32	Use of prefabricated units and standard materials	32	Adequate building technique
33	Interaction between different designers (Architects and Engineer)	33	Establish systems of rewards and punishments for material saving
34	Utilization modular designs	34	Proper management workers support
35	Reduced design complexity	35	Awareness among practitioners on managing waste
36	Explicit detailing in design	36	Staff vocational training
37	Interpretable design and specifications	37	Ensuring that good quality workmanship is achieved
38	Experienced designer	38	Appropriate material utilization
39	Proper management of design process	39	Availability of good work-life balance
40	Error-free design	40	Engaging competent workers
41	Proper monitoring and supervision of work	41	Adherence to specifications
42	Readable dimensions and specifications	42	Regular site meetings
43	Proper design information and consultation	43	Better storage facilities and environment/area
44	Adherence to clients' brief	44	Improved method of material usage
45	Sufficient time for design	45	Standard evaluation and comparing with specification
46	Early engagement of designer	46	Proper material protection against weather
47	Experienced personnel in planning	47	Adherence to design and specifications
		48	Adherence to waste management regulations and waste management throughout the entire project lifecycle
		49	On-site and offsite re-use of waste, separation of hazardous waste and on-site waste sorting

To achieve Effective Construction Material Waste Management (ECMWM) in any construction project, material waste must be controlled at its sources and causes and at different stages of a project. This will in turn control a coefficient of cost overrun for that project (Saidu and Shakantu, 2016a). To accomplish this, Figures 3 and 4 show the interrelationship between project stages (pre-contract and post-contract), ECMWM, material-waste sources, material-waste causes and the percentage coefficient of cost overrun.

Figure 4 shows that, unless construction-material waste control (ECMWM in Table 3) is tight at all sources and causes of material waste and at the stages of a project otherwise, cost overrun is bound to occur.

For example, as shown in Figure 3, if control is loose at the stages of a project (pre-contract / post-contract) or at material waste sources / causes, the project may likely overrun its initial budget by certain percentage. In Figure 3 the overrun is shown as a heavy weight in red ink pulling down the project. Though, the overrun may not completely be occasioned by material waste alone, but by a coefficient /certain percentage while the other remaining percentage may be caused by other factors, such as macro and micro economic variables and so forth (Saidu and Shakantu, 2016a).

The information in Figure 3 is further represented in Figure 4 (VENN diagram of SET theory in mathematics) showing the interrelationships and intersections between material waste causes, material waste sources, coefficient of cost overrun, project stages, and ECMWM. As stated earlier, the cost overrun must be a coefficient (a percentage), because it cannot be completely caused by material waste in a complete project. Figure 4 shows how ECMWM could be utilised through a simple mathematics equation to eliminate the likely coefficient of cost overrun for a project. To achieve this, three thin lines were drawn from one end to the other in order to form a triangle within the three intersecting circles. The three lines ends were labelled A, B and C with the running lines labelled as line 01, A-B; line 02, A-C; and line 03 B-C respectively. For instance, line 01, A-B forms the hypotenuse of a right-angle triangle which is completed with doted lines meeting at the ECMWM. This will be used as one of the equations that would determine how the coefficient of cost overrun would be directly eliminated with a complete application of ECMWM in a project. The same applies to other lines (line 02, A-C and line 03, B-C). The assumption here is that, if waste management and control processes are completely applied (100%) in a project, the coefficient of the cost overrun for that project can therefore be completely eliminated and *vice versa.* The coefficient of cost overrun identified from the literature (Figure 2, average percentage relationship between material waste and cost overrun) was 0.8681.

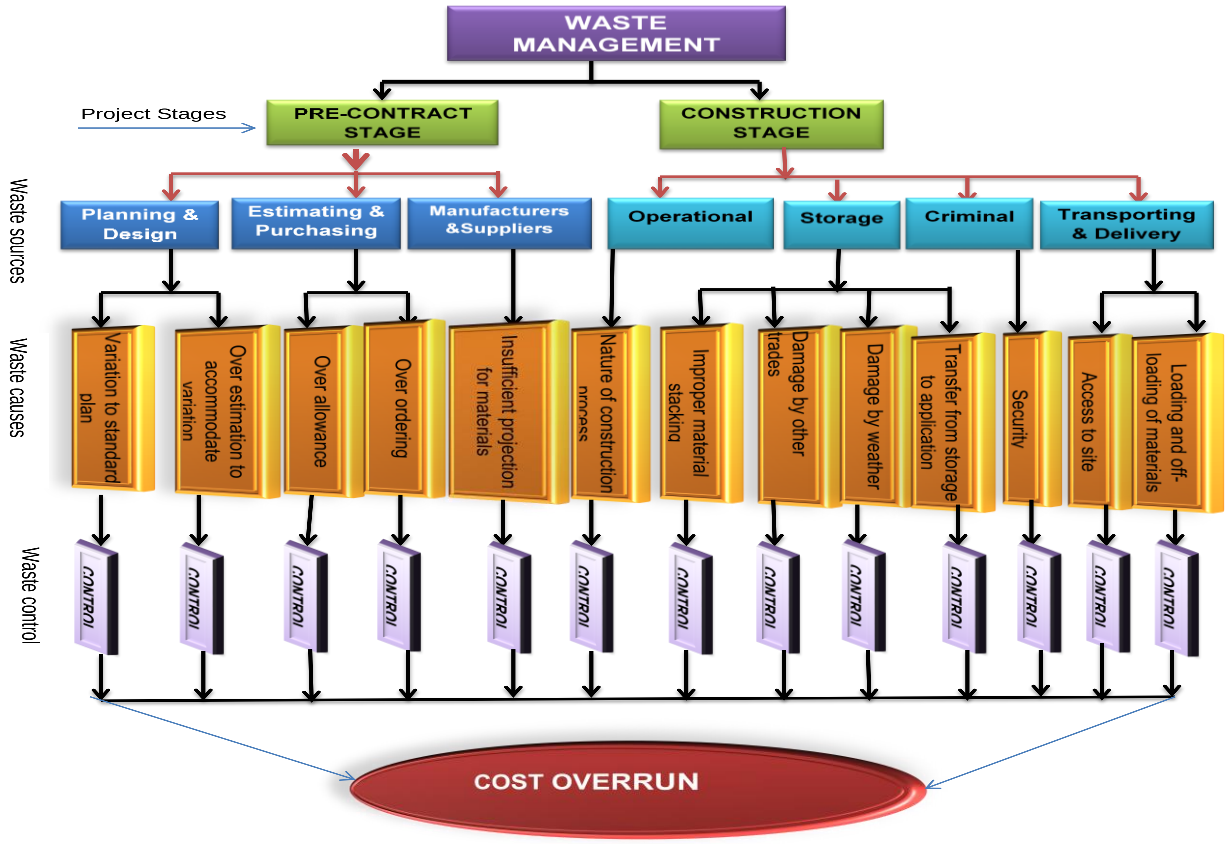

Figure 3. Summary of the relationship in Figure 2

This interrelationship is shown in Figure 4.

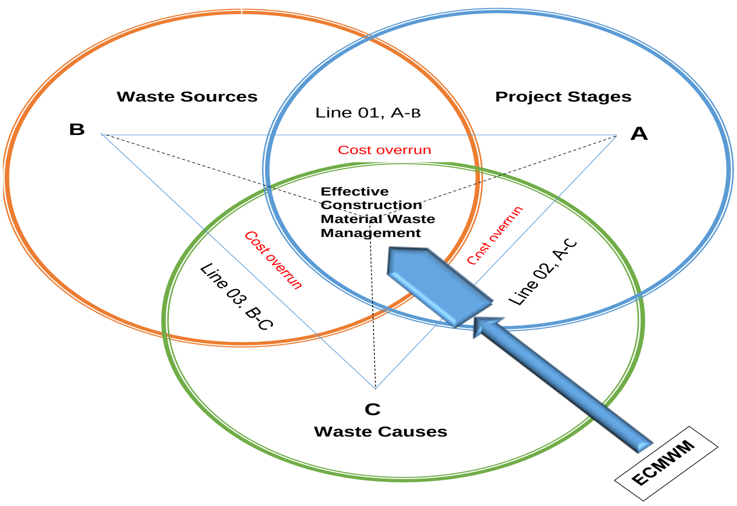

Figure 4: Relationship between project stages, waste sources, waste causes, management and cost overrun

This relationship is further represented mathematically showing how the coefficient of cost overrun is minimised/eliminated with Effective Construction Material Waste Management (ECMWM) from each scenario.

Line 01, A-B:

Considering line 01, A-B. This includes four (4) main issues namely: the project stages (A), waste sources (B), ECMWM (general intersecting point), and the coefficient of cost overrun (intersection between A and B) which is required to be minimised/eliminated.
The equation can be written as:

$$Project\ stage + waste\ Sources + ECMWM + (-\ 0.87\ cost\ overrun) = 0 \quad (1a)$$

This can be re-written as:

$$Project\ Stage\ +\ Waste\ Sources\ +\ ECMWM - 0.87\ Cost\ overrun\ =\ 0 \qquad (1b)$$

By making "ECMWM" the subject, it will change to positive (active) and the equation will be:

$$ECMWM\ =\ Project\ stage\ +\ Waste\ sources - 0.87 Cost\ overrun \qquad (1c)$$

This means that active ECMWM at stages of projects (pre-contract and post-contract) and at sources of material waste would effectively minimise the cost overrun by 0.87.

However, if ECMWM is negative (inactive) at project stages and waste source, then the coefficient of cost overrun must remain positive and active as shown in equation 01d.

$$0.87\ Cost\ overrun\ =\ Project\ Stage\ +\ Waste\ Sources - ECMWM \qquad (1d)$$

This is the same with other scenarios Line 02, A-C and Line 03, B-C.

Line 02, A-C:

$$Project\ stage\ +\ waste\ causes - ECMWM\ =\ 0.87\ cost\ overrun \qquad (2a)$$

$$Project\ stage\ +\ waste\ causes - 0.87\ cost\ overrun\ =\ ECMWM \qquad (2b)$$

This means that effective management of waste causes at project stages would effectively minimise project cost overrun by 0.87.

However, by making ECMWM inactive and negative, cost overrun will change and take over the positive position in a project as shown in equation 02c.

$$0.87\ Cost\ overrun\ =\ Project\ Stage\ +\ Waste\ Causes - ECMWM \qquad (2c)$$

Line 03, B-C

$$Waste\ sources\ +\ waste\ causes - ECMWM\ =\ 0.87\ Cost\ overrun \qquad (3a)$$

Collecting the like terms by making "ECMWM" the subject, the equation will be:

$$Waste\ sources\ +\ waste\ causes - 0.87\ Cost\ overrun\ =\ ECMWM \qquad (3b)$$

Therefore, an "ECMWM" would minimise the occurrence of "cost overrun" by 0.87. However, poor "ECMWM" would lead to occurrence of "cost overrun" as shown in the equation below:

$$-ECMWM\ =\ Project\ stage\ +\ Waste\ sources\ +\ 0.87\ cost\ overrun \qquad (3C)$$

Scenario 1 (Line 01, A-B), shows that waste sources within the project stage. Figure 6; cause an 4% cost overrun. Therefore, to effectively control the project waste, there must be an Effective Construction Material Waste Management (ECMWM) at the project stages and at the waste sources, which will in turn, minimise cost overrun by 0.87. The same applies to the remaining two other scenarios.

5.0 Conclusions and Further Research

Material waste and cost overrun are identified as global problems which affect the success of many construction projects. These are occasioned by several causes at different stages of projects. Identification of these causes at different stages and the application of relevant control measures to minimise their occurrence is a step towards alleviating the consequences. Moreover, most managers of construction projects pay little attention to the effects of waste generated on cost overrun. The aim of this research was to examine the relationship between the causes of material waste and those of cost overruns with a view to suggesting the possible ways of minimising their effects at the pre-contract and the post-contract stage of a project. The study reveals an average of 86.81% relationship between the causes of material waste and those of cost overruns at the pre-contract and post-contract stages of a project. 100% of the causes of material waste were found among the causes of cost overruns at the pre-contract and the post-contract stages of a project, while 96.88% and 81.36% of the causes of cost overruns cause material waste at the pre-contract and at the post-contract stages respectively. Other causes which are not related are mostly, the micro-economic and macro-economic factors. It was also found that to achieve effective construction material waste management for any construction project, material waste must be controlled at its sources and causes, and at different stages of a project.

Based on these findings, it can be concluded that effective management of material waste would translate into a reduction in the level of cost overrun by 86.81%. The study recommends that management of material-waste causes should be encouraged, as it has the potential to minimise the causes of cost overrun for a project.

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