



**EFFECT OF BUILDING MATERIALS COST ON HOUSING DELIVERY TOWARDS
SUSTAINABILITY**

by

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ABSTRACT

The study investigates the predominant factors responsible for increase in the cost of building materials and the effect of this cost increase on housing delivery in Western Cape, South Africa.

Sustainable housing is buildings produced to meet the present housing needs of people without conceding the ability of the future generation to meet their future needs. However, a significant increase in the cost of building materials has been a major constraint to the delivery of sustainable housings, as made evident in the literature, leading to project cost and time overruns or even project abandonment. However, building materials consume up to 65% of the total cost of construction. This factor on cost has, over the years, threatened the ability of the construction industry to deliver projects within budgeted cost, at stipulated time, and at satisfactory quality. This prompted the need to proffer solutions to these factors identified which are causing increases in the cost of building materials towards sustainable housing delivery in Western Cape. Based on this research study, housing is termed to be sustainable when it is available and affordable for the masses timely and at quality expected.

The research study adopted a mixed methodological approach, involving the use of semi-structured qualitative interviews and closed-ended quantitative questionnaires administered to construction stakeholders (architects, quantity surveyors, engineers, construction managers, project managers, site supervisors and material suppliers) in the Western Cape Province of South Africa. SPSS version 24 software was used for analysing the quantitative data collected and 'content analysis' method was used to analyse the information collected through the qualitative interviews.

The findings revealed that the major factors responsible for increasing the cost of building materials are inflation, wastages of building materials by labourers, cost of transportation and distribution of labour, design changes, client contribution to design change and change in government policies and regulation. Moreover, the research showed that fluctuation in the cost of construction and high maintenance costs due to poor workmanship also impact the cost increase of building materials for housing delivery. In addition, research findings affirmed that for optimum materials usage for the enhancement of sustainable construction, the following criteria should be considered in the selection of building materials: maintenance cost, energy consumption and maintainability.

The adoption of these findings by construction stakeholders in the South African construction industry would enhance the delivery of affordable housing at reduced cost, at the required time and at the expected quality. Therefore, an adequate implementation of the framework presented in this study will enhance sustainable housing delivery.

Keywords: Building materials, housing, housing delivery, material cost, stakeholders, sustainability and sustainable housing.

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DEDICATION

This thesis is dedicated to Temitope Jeje.

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DEFINITION OF OPERATIONAL TERMS

BUILDING MATERIALS: Building materials are any materials used in the erection of a building.

HOUSING: Housing is defined as any building or shelters that people live or a place of dwelling.

HOUSING DELIVERY: This is the process of supplying sustainable housing, at affordable cost and to a specified quality standard.

MATERIAL COST: This is the total cost of building materials (including purchase, handling and logistics).

STAKEHOLDERS: These are groups of individuals (internal and external participants) who work together to build, with the purpose of achieving the same objectives towards project delivery.

SUSTAINABILITY: Is the state in which available components of the ecosystem and their functions are maintained for the present and future generations.

SUSTAINABLE HOUSING: This is housing that is affordable and available to the present and future generation.

ABBREVIATIONS AND MEANING

4Ms: Money, Manpower, Machine and Materials

4Rs: Renewable, Reusable, Recyclable and Reduction

CDW: Construction Demolition Waste

CIDB: Construction Industry Development Board

FIFA: Federation International De Football Association

FMEA: Failure Mode & Effect Analysis

GDP: Gross Domestic Product

GHG: Greenhouse Gas

IAQ: Indoor Air Quality

ISO: International Organisation for Standards

LCA: Life Cycle Assessment

LCC: Life Cycle Cost

PMBOK: Project Management Body of Knowledge

QIM: Quality Inspection and Management

SPSS: Statistical Package for Social Science

TQM: Total Quality Management

VOC: Volatile Organic Compounds

ARTICLES FOR PUBLICATION

- Effects of increase in the cost of building materials on the delivery of affordable housing in South Africa.
- Factors responsible for increase in the cost of building materials that hinder sustainable housing delivery.

CHAPTER ONE

1.1 INTRODUCTION

Previous studies in building sector have indicated that building materials account for between 50 to 60% of the total construction input (Adedeji, 2012:1; Ogunsemi, 2010:2). Building materials constitute the largest single input in building construction, of which housing is one part. Adedeji (2012:2) revealed that the cost of building materials has been one of the factors prohibiting successful housing delivery. Nega (2008) opine that increase in costs of construction is caused by increase in the cost of building materials, an increase which has a significant impact on overall budgeted cost of construction. Construction cost has been the most significant consideration for the execution of any construction project. Previous studies have determined that delays in housing deliveries have resulted in client and contractor disputes, litigations and project abandonment, and cost and time overrun. Hence, there is a need to address this increase in the cost of building materials that are impeding the delivery of sustainable affordable housing that in the Western Cape of South Africa.

While excessive costs of building materials has significantly slowed down the housing delivery, nevertheless, the problem of increase in the cost of building materials cannot, be rationally minimised by using non-conventional building materials, without due consideration of the sustainability of these alternative materials, the appropriate initiative and the cost of processing. The theory of *sustainability* has called for major attention in the construction industry over recent decades.

Housing availability is characterized by its method of production as well as life cycle which enhances the economic stability of the inhabitants by taking into consideration – at every stage of construction – the use of land and materials resources (Solanke, 2015:2). Thus, to deliver sustainable housing, it is crucial to consider the implications of cost of materials and the resource availability (sustainability) from the housing design stage to construction stage in order to ensure adequate building materials' utilisation.

Thus, this research study provides information on the implication of increase in cost of building materials by examining its influence on the construction industry and the effect on sustainable and affordable housing delivery, and in order to proffer possible solutions for minimising cost of building materials to perpetuate sustainable housing delivery in the Western Cape, and all of South Africa at large.

1.2 BACKGROUND TO THE STUDY

Housing is a key factor in the sustainable development of a nation and a basic human need (Ganiyu, 2016:2). Developing nations are continuously challenged with issues of inadequate housing (du Plessis, 2002:1). Housing demand continues to grow in recent periods worldwide and is projected to continue escalating (Wood, 2007). Ganiyu (2016:2) stated that the benefits of sustainable buildings are more than just reducing the negative impact of buildings on public health, but rather buildings must be cost effective, improving occupant efficiency and enabling community development. Cost plays a significant role in making decisions for the execution of sustainable construction (Kunzlik, 2003:185; Meryman & Silman, 2004:217). Ofori and Kien (2004) stressed that the additional cost required in many cases was the major constraint for sustainable construction implementation. Adedeji (2014) also revealed that cost of building materials has been a major constraint for sustainable housing delivery.

Building materials can amount to 50% of the total cost of all projects in the construction industry (Agapiou *et al.*, 1998:132). While building material cost is subject to demand and supply, it is also affected by many other factors, including quality, quantity, time, place, buyer and seller. However, more factors affecting cost of building materials include currency exchange, material specification, inflation pressure and availability of new materials in the country (Elinwa & Silas, 1993:699). Furthermore, the total cost of project is influenced by various factors such as improper material handling and management on site during construction production processes, all of which impact the time and quality of the project (Che *et al.*, 1999:70).

Ogunlana, Promkuntong and Jearkjirm (1996:40) are of the opinion that project deliveries are delayed primarily as a result of incomplete construction drawings, material management inefficiency, material wastages and site worker inefficiencies. Therefore, material management in construction has been a source of critical concern to contractors for decades (Linden & Josephson, 2013:91) and thus necessitates effective material management in controlling productivity and cost (Kasim *et al.*, 2005:794). Similarly, Solanke (2015:4) suggested that the utilisation of material tactics helps in attaining orderliness and avoids material wastages on construction sites. The literature reviewed revealed that materials wastages on construction sites are a result of excessive purchase of materials, extended storages, material abandonment and unclear design specifications during production. Thus, it is high priority that material resources be managed properly to reduce waste, and achieve timely project delivery at the budgeted cost and acceptable quality.

Asif *et al.* (2008) described *sustainability* as the ability to meet present needs of stakeholders without impeding on the future quality of life due to extreme use of ecological resources, social impact and economic loss in a region. In order to meet the housing demand, the developments must be affordable and sustainable as well, thereby making smart use of sustainable building materials. The prerequisite for undertaking any development is that the products are functional and economically cost effective and available within the shortest time (Ihuah, 2015:219). Conversely, persistent increases in the cost of building materials is projected to work against this, as this increase in cost of building materials affects the current demand greater than the available supply, so some development projects are then abandoned and left uncompleted (Ihuah, 2015:219).

The sustainability of a building depends on the decisions taken by the stakeholders in the construction process: owners, managers, designers and firms, for example (Akadiri, 2011:3). The pace of actions towards sustainable application depends on the awareness, knowledge and understanding of the consequences of individual actions (Braganca *et al.*, 2007:7; Abidin, 2010). Among these is the environmentally responsible approach to the selection of building materials (Anderson *et al.*, 2009: 223). The material selection process is a complex process influenced and determined by numerous preconditions, decisions and consideration (Wastiels & Wouters, 2009: 379). The selection of building materials is one of several factors that can impact the sustainability of a project (Nassar *et al.*, 2003: 545). An appropriate choice of materials for a design process plays an important role during the life cycle of a building (Treloar *et al.*, 2001:140; Zhou *et al.*, 2009).

Resolving the housing delivery problem entails a holistic approach towards building houses that are not only affordable but equally sustainable (available) to both the present and future users. Hence there is a need to investigate the effects of cost of building materials on housing delivery, which this research intends to achieve through the conceptual framework represented in Figure 1.1, a conceptual framework presenting the effect of cost of building materials, typical selection criteria, and typical factors responsible for the cost of building materials, encapsulating the direct and functional relationship of these variables for sustainable affordable housing delivery process.

The conceptual framework for this study is illustrated in Figure 1.1.

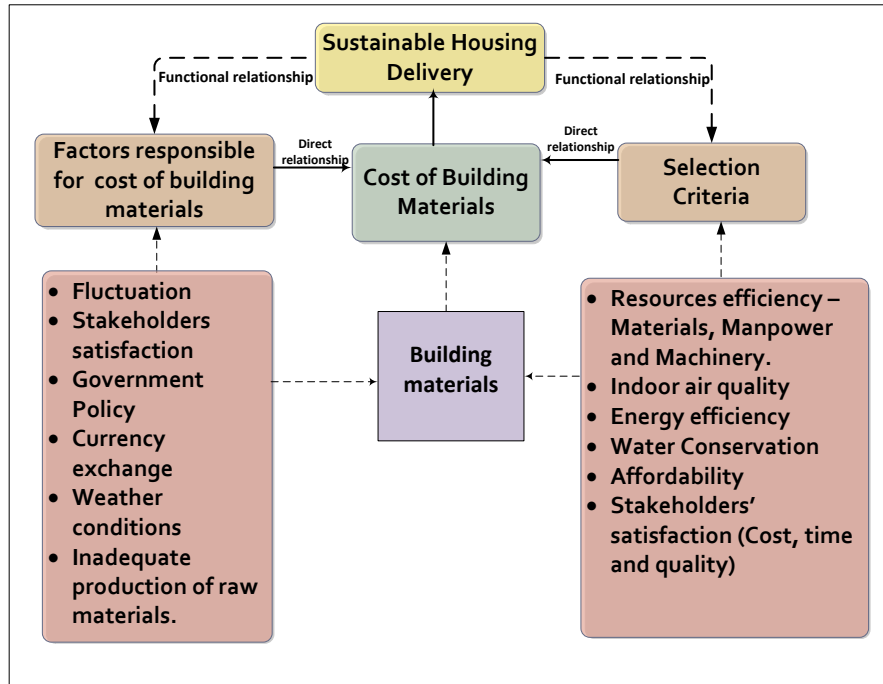


Figure 1.1: Conceptual framework

1.3 Problem statement

The demand for housing of all types, coupled with inflation and monetary supply, poses a significant challenge to the cost of building materials in the construction industry (Eshofonie, 2008). The problem of high costs of building materials militate against effective delivery of sustainable housing as building materials play such a necessary and substantial role in the construction of housing.

Jagboro and Owoeye (2004:10) established that increase in the price of building materials has multiple effects on housing development. Significant increase has brought about loss of client confidence in consultants, as well as added asset risks, inability of developers to deliver affordable housing and loss of investment in the construction industry. Therefore, an improved sustainable housing delivery within budgeted time, cost and expected quality, taking into consideration stakeholder satisfaction and cost of building materials is an absolute necessity.

1.4 AIM AND OBJECTIVES OF THE RESEARCH

1.4.1 Aim

The aim of this research is to investigate the effects of building materials cost on the delivery of sustainable housing.

1.4.2 Objectives

The objectives of this research are as follows:

1. to examine factors responsible for increase in cost of building materials that ultimately hinder sustainable housing delivery;
2. to evaluate the effects of increase in the cost of building materials on the delivery of affordable housing;
3. to ascertain the criteria to be considered in the selection of building materials for sustainable affordable housing; and
4. to establish solutions to factors causing increase in the cost of building materials towards sustainable affordable housing delivery.

1.5 Research questions

The research questions to be addressed are as follows:

1. What factors are responsible for increase in the cost of building materials?
2. What are the effects of high cost of building materials on affordable housing delivery?
3. What are the factors to be considered in the selection of building materials for sustainable affordable housing delivery?
4. How could building materials enhance affordable sustainable housing delivery?

1.6 Significance of the study

This research will enable clients, contractors and consultants to take an economic approach to housing delivery, such that they would be able to identify the predominant factors leading to increases in the cost of building materials in the Western Cape. The application of the solution to minimise cost of building materials will enhance client confidence in consultants, reduce investment risks, and generally boost the viability and housing sustainability. Also, this research will educate the general public on the implication of upward increase in the cost of building materials on affordable housing delivery in Western Cape. The research outcome ultimately will sensitize the South African government to the need to implement policies for reducing the cost of building materials in the Western Cape and thereby encouraging massive sustainable affordable housing delivery within the province.

1.7 Research methodology and design

When undertaking research it is important to choose the correct methodology to ensure that research objectives are met and the findings are valid (Steele 2000:16; Fellows & Liu, 2003:21). A preliminary pilot study was conducted by administering questionnaires to construction practitioners (target groups) to identify the factors and evaluate effects of increase in the cost of building materials in the construction industry of the Western Cape of South Africa. The pilot study focused on factors responsible for increase in the cost of building materials, the effect of increase in cost of building materials on housing delivery, and then criteria to be considered in the selection of sustainable building materials.

The pilot study aided in the formulation of the research questions and objectives for a precise and modified questionnaire, one which would thoroughly investigate the interests of this research.

1.7.1 Research design

Leedy and Ormrod (2010) specified that the research method and design adopted in a research determines its uniqueness and eventually the success of the research. The nature of a research topic, its aim and objectives and the resources available largely determine its design (Creswell, 2003:6), as a research design can be qualitative, quantitative or a combination of the two (Creswell *et al.*, 2011). Thus, the *mixed method research approach* combines quantitative and qualitative methods for data collection (Clark *et al.*, 2008). The research design adopted in this study focuses on the procedures, rules and guidelines in line with the aim and objectives of the study. Therefore, the mixed method approach was adopted for this study: a quantitative research approach with construction stakeholders was validated using qualitative interviews with construction site supervisors.

Table 1.1 Relationship between research objectives, research questions and research methods

RESEARCH OBJECTIVES	RESEARCH QUESTIONS	RESEARCH METHODS
To examine factors responsible for increase in cost of building materials that ultimately hinders sustainable housing delivery	What are the factors responsible for increase in the cost of building materials?	Review of relevant literature and analysis of questionnaires and interviews
To evaluate the effects of increases in the cost of building materials on the delivery of affordable housing	What are the effects of cost of building materials on affordable housing delivery?	Review of relevant literature and analysis of questionnaires and interviews
To ascertain criteria to be considered in the selection of building material for sustainable affordable housing delivery	What are the factors to be considered in the selection of building material for sustainable affordable housing delivery?	Review of relevant literature and analysis of questionnaires and interviews
To establish solutions to the factors causing increases in cost of building material towards sustainable affordable housing delivery	How could building materials enhance the affordable sustainable housing delivery?	Review of relevant literature and analysis of questionnaires and interviews

1.7.2 Population of the study

The population of this study comprises construction stakeholders and site supervisors in the Western Cape, South Africa.

1.7.3 Instrument for data collection

Primary and secondary data collection methods were adopted in the research study. The primary data was collected using structured open-ended and close-ended questionnaires in conformity with the research objectives. The secondary system of data collection for this study involved an extensive review of relevant literature – primarily previous research – which includes a review of published conference papers, textbooks, published article in

academic journals. In addition, qualitative interviews are used to validate the findings obtained through the quantitative research.

1.7.4 Administration of instrument

The questionnaires were self-administered to obtain general information from the respondents as well as more specific information sought to meet the objectives of this study.

1.7.5 Techniques of data analysis

Quantitative data were analysed using a generic software package known as the Statistical Package for Social Science (SPSS version 24). The Likert scale is used to determine the range of each respondents agreement or disagreement to statements by a ranking of 1-4. Data gathered from questionnaires were analysed using descriptive statistics. Content analysis was used to analyse the qualitative data gathered and each interview was transcribed and checked for accuracy for respondent validation. A reliability test of the data collected was assured by the Cronbach's Alpha Co-efficiency test.

1.7.6 Scope and limitation of the study

Information was gathered from construction stakeholders and materials suppliers in the Western Cape of South Africa. Respondents for this study include the various stakeholders in the construction industry.

1.8 Key assumptions

This study assumes the following:

- Selected construction companies face challenges with the high cost of building materials on site.
- Questionnaires were designed to ask relevant questions in regard to the research objectives and research questions.
- The research population provides relevant information to inform and justify the study objectives and research questions.

1.9 Ethical considerations

All names of participants (organisations and individuals) remains anonymous on all research documents, with respondent particulars guarded with extreme privacy. Research participants (organisations and individuals) are not be paid or compensated any way whatsoever for participation. The research quality is assured by validating quantitative data with the conduction of qualitative interviews.

1.10 Thesis structure

The thesis will be structured as follows:

Chapter One: Introduction –This introductory chapter comprises the background of study, statement of problem, research questions and objectives, methodology, limitations, key concepts, significance of study and the chapter outline.

Chapter Two: Literature review – The literature review emphasises previous works of various researchers related to this study of the construction industry, in textbooks, articles, journals and dissertations affiliated with sustainable development, effects of cost of building materials on housing delivery, factors responsible for increase in the cost of building materials and criteria for selection of sustainable building materials.

Chapter Three: Methodology – This chapter presents the research method adopted in the study towards achieving the research aim and objectives. Additionally, this chapter examines the research design, research population, sampling technique, instrument for data collection, administration of instrument, technique for data analysis and model formation.

Chapter Four: Analysis and discussion — This chapter provides information from the elicited data, while also analysing the results obtained in the study, discussing the research findings, and further representing results in both graphical and tabular formats.

Chapter Five: Summary, conclusion and recommendations – This chapter presents a summary of findings, overall conclusions drawn and final recommendations made for further study.

1.11 Research process

Figure 1.2 illustrates the process of the research from inception to completion.

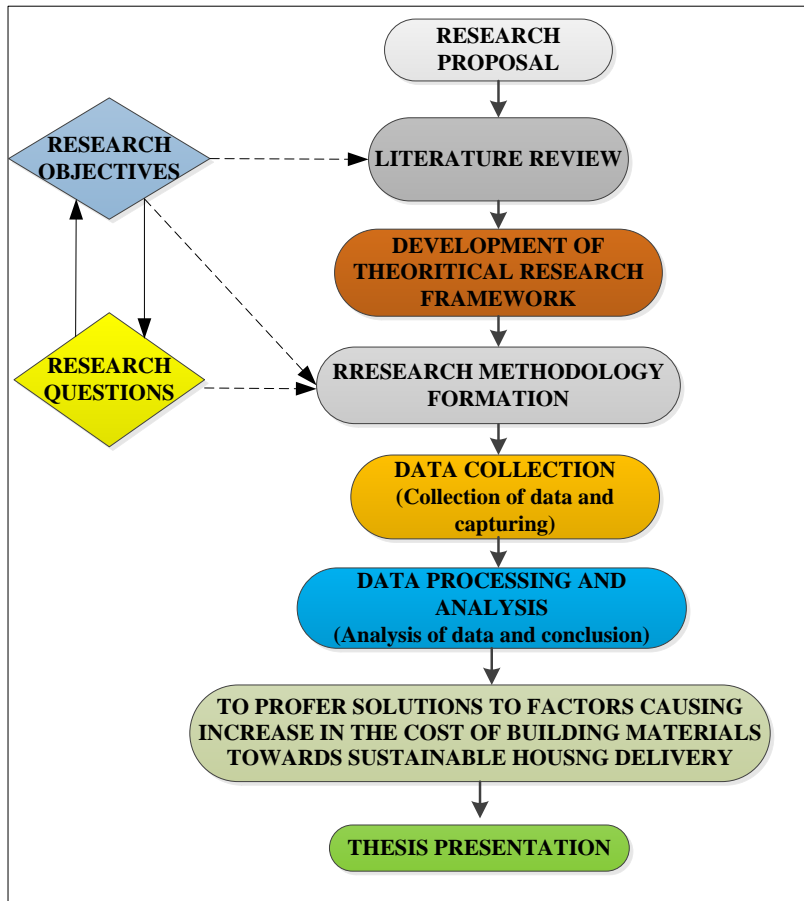


Figure 1.2: Research process

1.12 Chapter summary

This chapter provides an overview of this research. The background, research aim, research objectives, research questions, significances, scope and limitations, literature review and methodology of research were all briefly discussed. The subsequent chapters elaborate on the literature review, research methodology, analysis and discussion of results, conclusions and recommendations derived from the research.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the review of relevant literature to establish the background of the building industry, discussing the factors responsible for increases in the cost of building materials and factors that commonly cause overrun costs in the construction industry. The effects that increases in the cost of building materials have on the delivery of housing, criteria to be considered in the selection of sustainable building materials for the delivery of a sustainable housing in terms of cost, time and quality, and possible solutions to any detrimental factors responsible for the increasing cost of building materials, will also be discussed in this chapter.

2.2 Construction Industry

An appropriate, available and sustainable shelter is indispensable: a true basic need of all human beings. Thus, housing options must constantly be available, affordable and certainly durable in the built environment (Ihuah, 2015). The construction industry is one of the most important industries underpinning the economic development of any nation (Ofori, 1999). Uwakweh (2005) concurs that the construction sector makes undeniably important contributions to the socio-economic expansion process in developing countries by contributing meaningfully to the gross domestic product. The National Treasury of the Republic of South Africa (2012) described the *building construction industry* as a broad collection of industries and sectors adding value in the creation and maintenance of fixed assets within the built environment. Notably, Windapo and Cattell (2013) observed that the construction industry must operate as a single unit rather than as a complex cluster of industries in which building materials sector is among them. The construction industry plays a very essential role in all developed and developing countries. In Europe, for example, the construction industry is the key industry on the entire continent, employing more than 7% of all European workers (Proverbs, Holt & Olomolaye, 1999:198). In the US, the construction sector contributes 14% to the gross national product and some 8% of total employment (Thibolt, 2002:567). Similarly, the South Africa construction industry has a share of 5.8% of the gross domestic product, employing approximately 7% of the South African workforce (Statistics South Africa, 2012).

FIFA 2010 brought noteworthy changes to the South Africa construction industry (Windapo & Cattell, 2012). The construction industry accounts for approximately 9% of the gross domestic income (GDI), and the gross fixed capital formation (GFCF) contributes over 35% to the country (CIDB, 2004a: online). Therefore, there has been a severe increase in the GDI of the South African construction industry with over two hundred and sixty-eight million rand (R268 million) between 2007 and 2011 (Solanke, 2015:22). This is evidence that the construction industry is an active driver of the socio-economic development in South Africa (Windapo & Cattell, 2013). Similarly, the building material industry contribution to the economy of any nation cannot be overemphasized, as its output governs both the rate and the quality of construction work (Akanni *et al.*, 2014).

Conversely, the construction industry has inherent disadvantages as well: the construction sector plays a significant role in unsustainable development and this could be attributed to urbanisation, industrial activities, unruly use of natural resources and unplanned rapid population growth (Son *et al.*, 2011:337). By virtue of its size, construction industry is one of the largest consumers of energy, material resources, and water, and also a formidable polluter of the environment (Ding, 2008; Ding *et al.*, 2010).

Materials such as stones, wood, straws, clay, lime, and brick occurred naturally as building materials (Akanni, 2006:14; Taylor, 2013:100). Due to improvements in technology and science at the beginning of the 20th century, materials with better performance and durability were introduced, for example, reinforced concrete, steel, plastic and metal (Taylor, 2013:101). The process of housing development *must* be based on principles of sustainability, which should be applied throughout the process from conception, construction and final use of the buildings (Adedeji, 2012). The enormous percentage of building materials that make up to the total cost of construction project costs make it an essential component with a massive effect on the cost of construction and basically the affordability (or lack of) of proposed construction projects (Windapo & Cattell, 2012). However, this could be exacerbated to the significant loss of performance capacity encountered within the South African construction sector. Windapo and Cattell (2013) explored thirteen critical factors that influence the performance, growth and development of the South African construction industry; the top critical challenge facing the construction industry was increase in the cost of building materials. Clearly, then, is it imperative to find solutions to this factor, and others, resulting in increase in building materials cost.

2.2.1 Construction stakeholders

Takim (2009) described *construction stakeholders* “as a group of people who have the ability to influence production process and final products of a construction project, whose quality of living and environmental statues are affected by positively or negatively by the project”. Similarly, Isa, Alisa and Samad (2014) noted that construction project stakeholders are a group of intellectuals incorporated in the scheduling/development phase of a building project to achieve cross-functional construction responsibilities. Takim (2009:169) and Yudelson (2010:41) added that for effective management of any construction project, an integrated project team is comprised of a wide range of professionals such as users (owners), general contractors, architects, project managers, consultants, engineers and government agents/commissioning authorities depending on the complexity of the project. Pheng and Chuan (2006:31) explained that the ability of construction team to effectively communicate and maintain a sharp and professional working environment is termed the ‘*team relationship*’. Construction activities on a project site will be accomplished through effective team work. Therefore, effective team work enhances adequate use of budgeted cost during production process (Cohn & Ralston, 2005).

Notably, the importance of stakeholders in any construction project is relative to attaining success and sustainability during construction (Takim, 2009:167; Menassa & Baer, 2014). According to Isa *et al.* (2014:42), making crucial decisions on sustainability implementation is the ultimate role of construction stakeholders in constructing housing that meet the demanding needs of the present generation without conceding the satisfaction of the future generation. One of the critical stages in building construction projects for sustainability integration is the planning process. Therefore, to attain an effective sustainable housing project, it is important for stakeholders to act together throughout the planning processes of the project (Isa *et al.*, 2014). In addition, Storvang and Clake (2014) further explained that the planning process provides a platform for stakeholder participation to add relevant perception to the construction process in a project.

The four (4) main construction project stakeholders who are accountable for sustainability performance and ultimately, the accomplishment of the project, irrespective of the nature and scope of the project in both developing and developed countries (Azmy 2012; Bal, Bryde, Fearon & Ochieng, 2013; Wang & Huang, 2006), are as follows:

- project owners;
- construction contractors;

- project managers; and
- government stakeholders.

Project owners, either in form of public or private entities – such as developers, clients or project land owners – carry the responsibility of securing construction contractors and consultants with qualified skill on sustainable building production so that they can estimate the worth of their investment and purchases (Solanke, 2015). Additionally, clients should be certain that sufficient financial requirements are ready prior to the commencement of any project (Eshofonie, 2008), as cost is one of the major, among numerous factors, with which consultants must grapple. The construction contractors and consultants include engineers, architects, quantity surveyor, materials suppliers who are principally in charge of producing construction documents and physically representing design documents either through subcontract or sub-subcontracted labour (Robichaud & Anantatmula, 2011). However, Solanke (2015) explained that ability to recognize the responsibility and influence of the stakeholder involvement in a project is one of the major qualities of a successful project manager. Also, the project manager should ensure that project owners are cognisant of the process of construction, the challenges and the strategies before and during project construction.

Government agencies undertake the role as overseers of building regulatory policies and codes that encourage the scope and objectives of sustainable building practices. The participation of local government as stakeholders in the planning phase will safeguard the project design plans in accordance with regulations (Perkins *et al.*, 2011)

2.3 Sustainable development and sustainable housing

Sustainability is “the ability to meet the present needs of humans without compromising the ability of the future generations meeting their own needs” (Du Plessis, 2007). ‘Meeting the needs of the present’ refers to the development aspects of sustainability, including economic issues (Ebsen & Ramboll, 2000). Therefore, sustainability should be the main principle undergirding housing design and one of the important dimensions of housing quality (Morgan and Talbot, 2001:321).

Thus, for development to be sustainable, it must take into account social and ecological factors, as well as economic ones, of the living and non-living resource base on long-term as well as the short-term advantages and disadvantages of alternative actions (Akadiri, 2011). Diesendorf (2000:34) defines *sustainability* as the goal of ‘sustainable development’ or ‘economically sustainable and socially just development’ which enhance the natural

environment and human well-being. Gibberd (2005:1606) views sustainability as a multifaceted interaction between ‘environment, society and economy’, and further pinpointed that these characteristics (environment, society and economy) are generally accepted as the prime contributors to sustainability. The idea of sustainability involves enhancing the quality of life, thereby empowering people to live in a healthy environment, with improved social, economic and environmental conditions (Ortiz, Castells & Sonnemann, 2009). However, Beder (1996:100), Berggren (1999:432), Stigon (1999:426) and Rohracher (2001) discussed the concept of sustainable development in the context of considering economic growth in addition to the social and environmental dimensions. Economic growth, with emphasis on aspects such as financial stability and material welfare creation, is the ultimate goal for every government to secure rising standards of living and increase the capacity of goods and services provisions to satisfy human needs. In spite of differing perceptions about the precise meaning and possible interpretation of the term *sustainable development*, it is widely accepted that for a development to be sustainable it must examine ecological, economic, social and ethical aspects of reality, as illustrated in Figure 2.1.

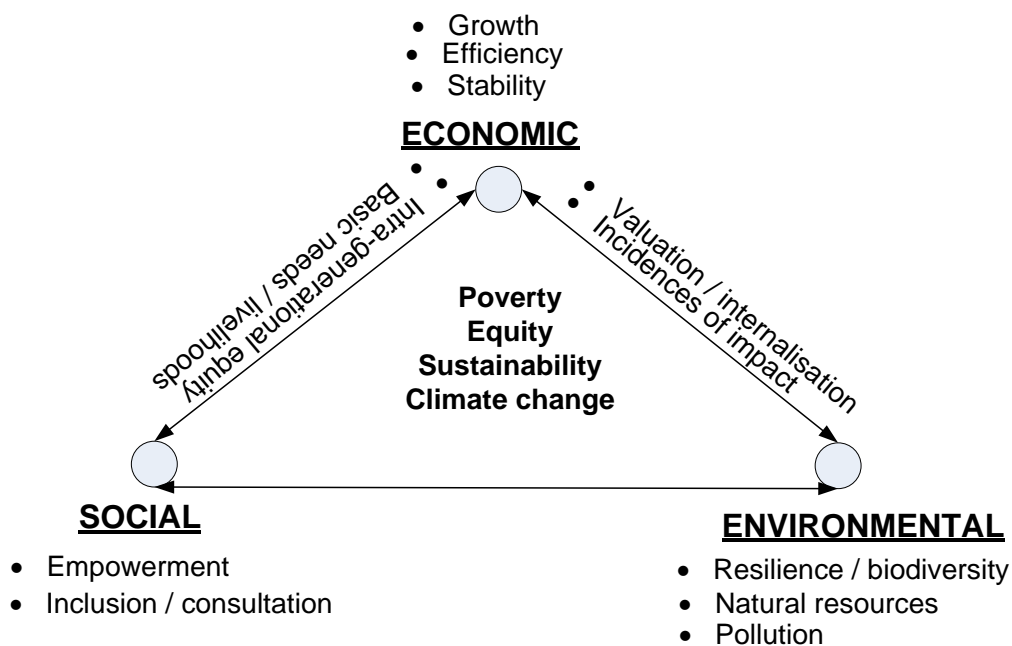


Fig 2.1: Sustainable development triangle

(Source: adapted from Munasinghe, 1994)

Figure 2.1 illustrates the relationship between humans, their environment, economy, society and technology, concepts which are well-supported in literature by many other researchers (Du Plessis, 2007:67; Bakhtiar, Shen & Misnan, 2008:56; Son *et al.*, 2011. Hill and Bowen

(1997), in Figure 2.1, highlighted the acceptability and relevance of each pillar to any construction project, placing emphasis on the importance of combining economics and ecological development planning (Akadiri, 2011:48). In order to attain sustainability in building construction, adoption of life-cycle assessment (LCA) as a standard of evaluation affords an improved quality of living for the inhabitants (Vatalis *et al.*, 2013). However, the sustainability level of a building, measurable using a Life Cycle Assessment tool (LCA), depends on the quality of materials used in construction and/or maintenance. Walker-Morison *et al.* (2007) further stated that sustainability in building production is efficiently measured when the accessible materials are utilized efficiently to decrease material wastes, environmental pollution and construction cost.

Sustainable housing means “housing which contributes to community building, to social justice and to economic viability at a local level (Morgan & Talbot, 2001:321). Thus, sustainable housing should meet a certain number of objectives in term of resource and energy efficiency, CO₂ and GHG (greenhouse gas) emissions reduction, as well as pollution prevention, mitigation of noise, improved indoor air quality and harmonization with the environment (John, Clement & Jeronimidis, 2005:139). Ideally, housing should be less expensive to build, last forever with modest maintenance, and be able to return completely to the earth when abandoned (Bainbridge, 2004:55). So, reach this ideal and develop truly sustainable housing, housing initiatives must be socially acceptable, economically viable, environmentally friendly and technically feasible (Choguill, 1999).

2.4 Building materials

Building materials play a vital role in the construction industry as they are those materials put together in erecting buildings; construction project is not feasible without the inclusion of building materials (Akanni *et al.*, 2014). Akanni *et al.* (2014) explained that building materials remain the most substantial input in project development and, because of this, play an undeniably significant role in the delivery of construction projects. According to Adedeji (2012), about 60% of total housing expenditure is spent on building materials. Notably, Karana, Hekkert and Kandachar (2010) indicated that appropriate use of the building materials, in respect of the expertise involved in the building construction process, determines the strength, functionality and quality of the building. Building materials play a crucial role in enhancing sustainability of buildings and contributing to economic wealth of the nation (Akadiri 2011:100). However, Donyavi and Flanagan (2011) observed that in order to reduce construction costs, and to improve productivity, quality and timely project delivery, material management effectiveness must be a main concern. The importance of building materials in sustainable housing delivery cannot be underestimated.

2.4.1 Factors responsible for increase in the cost of building materials

As discussed, the cost of building materials has presented a formidable challenge to the construction industry (Akanni *et al.*, 2014:1). Windapo and Cattell (2013:73) are in agreement, contending that the preeminent challenge affecting the performance of the construction industry and projects in South Africa is primarily the increasing cost of building materials. Hence, volatility tends to push the cost of building materials up and transfers a major risk to all parties involved: suppliers, contractors *and* clients (Li, 2001:689). Ughamadu (1993:30) also asserted that local currency devaluation was a factor surging the cost of building materials up.

Jagboro and Owoeye (2004:9); Mojekwu, Idowu, and Sode (2013:360); and Idoro and Jolaiya (2010:103), in their respective studies, pointed out many factors – such as the change in government policies and legislations, scarcity of raw building materials, fluctuation in the cost of fuel and power supplies, inadequate infrastructural facilities, unfortunate corruption, fluctuation in the cost of plant and labour, and seasonal changes – as being factors responsible for the escalating cost of building materials. Other factors responsible for the increase cost of building materials identified by researchers are these: fluctuation in the cost of transportation and distribution, political interference, local taxes and charges, fluctuation of cost of raw materials, cost of finance, inflation, and fluctuation in the exchange rate. Moreover, Oladipo and Oni (2012) analysed some macro-economic indicators impacting the cost of building materials, which include the following: exchange rate of local currency to other currencies globally, inflation rate and interest rate charge on loans.

Factors responsible for increase in the cost of building materials fall into four categories: economic related factors; building production related factors; external factors; and stakeholder related factors.

2.4.1.1 Economic related factors

2.4.1.1.1 Exchange rates

The *exchange rate* is the amount for which one currency is exchanged for another currency, used in determining the strength of one currency against another (Windapo & Cattell, 2012:192). South Africa produces its own strategic materials and yet relies on imported equipment. Therefore, increases in materials cost within the industry are a cause for concern (Windapo & Cattell, 2013:70). However, about 50% of all building materials and components incorporated into construction, or parts of the material ingredients required for the manufacture of the construction products, are sourced from overseas (Udeh, 1991). The

ratio to which building material costs are affected by exchange rates depends on the type and quantity of material being imported by a country at a specific time, the need to import the raw materials used in the production of building materials locally, and on whether or not local materials (such as copper, timber and steel) are internationally traded commodities (Windapo & Cattell, 2012:192). Oladapo and Oni (2012:132) opined that the introduction of the foreign exchange market has had a detrimental impact of the prices of building materials.

2.4.1.1.2 Inflation

According to Adamu (2013), *inflation* is an upsurge in general price level in any economy. It is primarily the measure of how the price of goods and services increase over time (Fichtner, 2011). Clearly, any other factor that delays a project will further expose the project to the risk of inflationary cost increases. However, Windapo and Cattell (2012:191) explained that there is a time interval between increase in inflation before resulting in actual increase in the cost of building materials. Due to the nature of the process and the rate of return for work undertaken on construction projects, the effects of inflation can mean loss of profit to contractors and higher cost overrun to project owners (Nega, 2008:57).

2.4.1.1.3 Interest rate

The high interest rate of banks and the unpredictability in the foreign exchange market result in serious depletion of a nation's foreign exchange resources, harshly affecting the industry with import dependence of about 60% of its raw materials (Jagboro & Owoeye, 2004:10). However, Oladapo (1992:16) opined that across the nation, many construction and profitable real estate projects and housing have either been put on hold or abandoned half way because of the scarcity of capital or because of the sky rocketing cost of borrowing.

2.4.1.1.4 Fluctuation in the cost of building materials

The studies of Rahman *et al.* (2013:518) revealed that fluctuation in cost of building materials was ranked as a significant factor of cost overrun. Frimpong *et al.* (2003) revealed price fluctuation as the most severe cause of project cost escalation. Zewdu *et al.* (2015) conducted a study to identify the factors causing cost overrun in Ethiopia, finding revealed that the main cause of cost overrun was fluctuations in cost of building materials, a fluctuation attributable to the limitation in exchange rate which in turn affects building material cost and the general cost level.

2.4.1.1.5 Inadequate production of raw material

Ogunlana, Krit and Vithool (1996:38) postulated that the reason for shortage of materials could be the ineffective supply of materials occasioned by general shortages in the industry, poor communication amidst sites and head office, poor purchasing planning and poor material coordination. Shortages of some construction materials may arise where the level of development activity is unusually high. If this had not been anticipated and integrated into the original cost estimate, the prices of these materials will increase (EU Framework 1998:13). Ensuring a timely flow of materials is an imperative responsibility of material management, as unavailability of material will likely result in delays and extra expenses (Rajaprabha *et al.*, 2016:1).

2.4.1.1.6 Supply and demand of building materials

Supply and demand of materials will determines the price of building materials (Oladipo & Oni, 2012:132). Windapo and Cattell (2012:191) stated that the demand for more housing and delay in supplying the building materials (or lack of materials), will add to the trends in the price of building materials, where the law of supply and demand can be related. Windapo and Cattell (2012:192) admitted that building materials cost increases are dependent on the market conditions under which they are manufactured. For example, the researchers noted that material cost will increases if only one or two companies are manufacturing building materials, as compared to those for which many manufacturers compete for the same market. A precondition for cost-effective construction is the availability of construction materials at the required time and location on site (Mohan *et al.*, 2002:627). Delay in the supply of materials on site is one causative factor of cost overruns in construction projects, particularly in developing countries.

2.4.1.2 Building production related factors

2.4.1.2.1 Site related factors

Construction waste becomes a universal concern faced by construction stakeholders. Waste generated during construction activities on site can affect delivery of a construction project significantly, specifically on construction cost, construction time, productivity and sustainability aspects (Nagapan *et al.*, 2012). According to Nagapan *et al.* (2012), the majority of waste generated during construction is materials waste, primarily as a result of the use of un-reusable materials, leftovers and debris. Unfortunately, this material waste amounts about 9% of the weight of materials purchased (Azis *et al.*, 2012:630). Material mismanagement during construction can lead to an increase in costs of construction,

whereas effective management of materials can bring extensive savings to project costs (Rajaprabha *et al.*, 2016:1).

Increase in material cost is primarily due to increase in transport charges (Windapo & Cattell, 2012:191). For example, Eshofonie (2008:19) noted that an increase in the cost of fuel will result in drastic increases in transportation costs. Hence, manufacturers raise the cost of building materials to cover the fuel increase when distributing the finished products from factory to suppliers and end-users.

2.4.1.2.2 Human factors

There are three typical resources associated with construction: material, machinery and manpower (3Ms). Manpower is the source of more threats than construction materials and machinery (Hanna *et al.*, 2005:734). In the study of Windapo and Cattell (2012:197), as they sought to benchmark respondents' perceptions against actual factors that may affect future building material prices in South Africa, it was revealed that labour cost had the highest correlation with building material prices, followed by transport cost. Notably, poor communication between management and labour can reduce morale of the labourers, further decreasing production while increasing project cost (Eshofonie, 2008:17). Mustapha and Rashid (2012:7) pointed out effective communication management as a key factor for improving the management of human resources in construction.

Many studies have been undertaken to explore the factors affecting construction labour efficiency. Previous studies undertaken by Kaming *et al.* (1997:26); Zakeri *et al.* (1996); Makulsawatudom *et al.* (2004:3); Eshassi *et al.* (2009:252); Ameh and Osegbo (2011); and Rivas *et al.* (2011:316) determined that shortages or unavailability of building materials on site is one detrimental factor affecting labour productivity and thereby increasing cost of construction over budgeted costs. Empirical evidence comes from a study conducted by Adebowale (2015:116): findings revealed delay and insufficient wages of construction labour as two of the top five labour-related factors affecting the efficiency of construction labour, leading to rework, reduced speed of work and poor overall construction performance (Ameh & Osegbo, 2011; Soham & Rajiv 2013; Durdyev *et al.*, 2012).

2.4.1.2.3 Design related factors

A construction project performance is inevitably impacted by design changes (Olawale & Sun, 2010). *Design change* is a kind of change that impacts the method of work as was originally planned budgeted or scheduled (Abdul-Rahman *et al.* 2015). However, it was further revealed by researchers that changes do frequently arise at any stage of a project due to a variety of reasons stemming from diverse sources – with significant impact. Zakeri

et al. (1996); Makulsawatudom *et al.* (2004); Enshassi *et al.* (2009); Dai *et al.* (2009); Ameh and Osegbo (2011); Jarkas and Bitar (2012); and Soham and Rajiv (2013) stated that the non- challenge attitude of design professionals to drawing queries (clarity, complexity and drawing errors) and inadequacies of information for production mean design challenges on construction projects. Oyedele and Tham (2006:2091) affirmed that there must be excellent communication between design team members, including simplicity, certainty, briefness and completeness of the design. Similarly, team-related matters such as team building, teamwork, team organization and team experience are frequently acknowledged as essential factors for project performance (Sanvido *et al.*, 1992:100). Hence, lack of significant consideration for these matters in the design phase may extend the project duration leading to cost overruns (Oyedele & Tham, 2006:2091).

Design change is connected to additional work, due to the absence of comprehensive briefing on the economic, functional and technical requirements of the project by the clients (Mansfield *et al.*, 1994). Abdul-Rahman *et al.* (2015) emphasized that design change orders resulting in additional work can account for as much as 50% of project cost overrun – quite substantial! Furthermore, additional work is a significant factor contributing to cost increases and schedule delays in construction projects. Wrong methods of estimation can be ascribed to lack of satisfactory experience of quantity surveyors (Mansfield *et al.*, 1994). Arguably, all these factors impinge significantly on the cost of materials.

2.4.1.3 Stakeholder related factors

2.4.1.3.1 Supplier default

Manavazhi and Adhikari (2002:630) found the factors responsible for supplier default come from the fact that some suppliers control a monopoly of the market by keeping the price high and restricting the output, showing little or no awareness of the needs of the customers. The researchers stressed that because of the high demand of some building materials, some suppliers wait for a high accumulation of orders, thereby generating problems associated with importing raw materials as well as increased exchange rates. The results of the study of Elinwa and Silas (1993:711) revealed that fraudulent practices and kickbacks was the second significant factor responsible for an increase in construction cost as perceived by construction professionals interviewed

2.4.1.3.2 Improper planning

Improper planning is one of the most important factors affecting the cost of building materials. Contractors should utilize all resources in effective ways. Proper scheduling is essential in project resource utilization, as the reverse, inadequate planning, will increase the

project cost (Eshofonie, 2008:15), suggesting that where there is no effective contractor scheduling and planning on site, these factors will be responsible for construction project delays (Assaf & Al-Hejji, 2006:351).

2.4.1.3.3 Delay in the supply of building materials

Timely delivery of building materials is essential. To this end, Ramanathan *et al.* (2012) revealed that quite a number of projects during building production processes experienced extensive delays in the supply of building materials, thereby exceeding the initial budgeted cost. Unavailability of building materials at the required time on site during construction frequently results in production materials deterioration and wastages, time wastage, low labour productivity and production cost overruns (Solanke, 2015). However, an effective material management system is significant during construction and for this, identification of materials should be made prior to the time of using the materials. This is an important step in avoiding late delivery of materials (Rahman *et al.*, 2012).

2.4.1.3.4 Client contribution to design change

While a change in a project's design can arise for any number of reasons, Ogunlana, Promkuntong and Jearkjirm (1996) acknowledged that clients are actually the major cause of change for many reasons: it could be for marketing purposes or due to an economic situation to meet customer demands. Also, adjustment or change might occur as a result of newly-emerging concepts perceived by the client for the project to achieve anticipated functional requirements. Alsuliman *et al.* (2012) further confirmed that clients initiate most of changes in building design which are likely to extend the delivery of projects at construction costs higher than budgeted cost. Arguably, changes ordered by clients will bear a consequence on the period of construction activities and increase the construction materials cost. A number of other studies have also shown that design changes are primarily caused by clients (Love, Frani, & Edwards, 2002; Memon *et al.*, 2014; Hamzah *et al.*, 2012).

2.4.1.4 External factors

2.4.1.4.1 Force majeure

Force majeure, otherwise known as 'Acts of God', is a term that covers a range of events, including revolution, war, riot, earthquake, landslide, fire, political and economic instability and other such risks (Nega 2008:53). Where it occurs, it will result in significant increase in the cost of building materials.

2.4.1.4.2 Weather conditions

While building materials are a significant component of any building project, climate change directly or indirectly will also have an effect on the use of building materials before or during building construction. Climate changes contribute a vast challenge to global warming emission of CO₂ by buildings under construction and in use (Windapo & Cattell, 2013:70). As actual site conditions for a construction project are not usually determined until construction begins, some changes may occur due to hostile weather conditions or changes in sub-soil conditions (EU Framework, 1998). Hence, unanticipated changes in sub-surface and surface ground conditions can sometimes involve major changes in the design of a project at great expense; potentially further increasing costs of constructional materials and adding to construction project delay. For example, a study by Rajaprabha *et al.* (2016) revealed that heavy rainfall has an effect on the concreting works for structures, which no doubt will then require extra materials and time.

2.4.1.4.3 Government policies

Windapo and Cattell (2013:70) noted that the South African Government has passed more than 1,000 pieces of legislation since 1994, which in turn procreated several regulations, giving the impression of over-regulation. According to Mansfield, Ugwu, and Doran (1994:255) and Obadan (2001:15), the building materials sector is one that government policies established. In the findings of Dlakwa and Culpin (1990: 238) and Adekoya (2003:29), one of the factors affecting the cost of building materials in the Nigeria construction industry was identified as government fiscal policies. According to Mansfield *et al.* (1994: 255), governments may also invoke their powers to initiate or halt projects on political, social and environmental grounds. Thomas and Martin (2004) stressed that no construction work happens in a single space; rather it is subject to a group of powers from regulatory control to political intervention. Among other external factors responsible for increase in cost of building materials is the lack of proxy substitutes for some building materials.

2.5 Construction project consideration

Cost, quality and time are the three major factors significantly essential in any construction project (Lambropoulos, 2005:452). Nonetheless, the primary goal of the construction project manager is accomplishing successful completion of the construction project within the predefined time, budgeted cost and expected quality checks (Lambropoulos, 2005:452). Kerzner (2013) emphasized that the process of project management is labelled successful when the project objectives are achieved within time, cost and desired technological level.

Consequently, the management of construction projects entails an in-depth knowledge and understanding of present management techniques, designs and construction processes (Koskela & Howell, 2001). For effective sustainable project management, the project managers require credible skills involving controlling, organising, planning, forecasting and co-ordinating (PMBOK, 2008; Kerzner, 2013). Hence, effective project management is achievable by the application of several management techniques during construction (PMBOK, 2008:67). Figure 2.2 illustrates the application of project managerial processes in construction project.

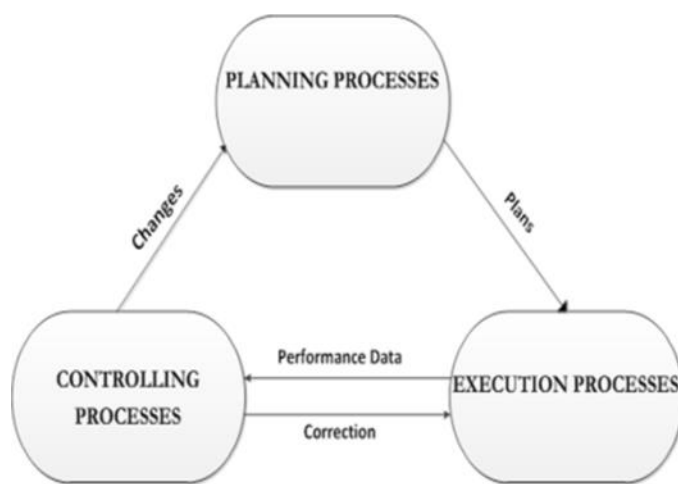


Figure 2.2: Managerial processes in construction project management

(Adapted from Koskela & Howell, 2001:186)

2.5.1 Cost consideration

Cost consideration is a major key throughout project management life cycle, regarded as one of the most important parameters of a project *and* the driving force of project success (Memon *et al.*, 2010:42). However, Chitkara (2006:106) delineated the elements of cost to include labour costs, material costs, plant and machinery costs and other, often unidentified, expenses. These, for ease of estimation, are grouped into direct and indirect costs. *Direct costs* are the costs ascribed to the construction workforce carrying out a job with the use of specific materials and equipment. On the other hand, the costs ascribed to overhead, profit and bond are known as *indirect costs* (Knutson *et al.*, 2009:149). According to Chitkara (2006) direct costs fluctuate from about 65% to 93% of the total costs. Hence, Achuenu and Ujene (2006:99) posited that the average proportions of material costs in the components investigated vary between 42%-77% in public and private projects, while the average proportion of labour costs vary between 23% and 58% in public and private projects in some selected states in Nigeria. Thus, in construction projects, the cost of materials and plant

components represent approximately 70% of the project sum in civil engineering projects, while material cost represents 45%-50% in housing and commercial building projects (Donyavi & Flanagan, 2009:12).

The primary factors affecting project costs are qualitative, such as client priority on construction time, contractor planning capability, procurement methods and market conditions, including the level of construction activity (Elchaig *et al.*, 2005:534). Similarly, Chan and Park (2005:295) are of the opinion that cost is affected by a number of factors precisely because the construction industry is multidisciplinary and its work integrates many stakeholders. For that reason, the consequences of poor cost anticipation and ineffective management are cost overrun, delay and abandonment of project, loss of profit, bankruptcy and insolvency by contractors. Oyewobi *et al.* (2011: 147) and Ogunsemi and Aje (2006:34) found other consequential losses are loss of quality, client dissatisfaction and disputes among stakeholders.

Cost overrun appears to be a common occurrence, accompanying virtually all projects in the construction industry (Azhar *et al.*, 2008:500). Moreover, Kasimu (2012:775) contended that cost overrun problem is more rampant than time overrun. Flyvbjerg, Holm and Buhl (2002:281) conducted comprehensive research on cost overrun in the construction industry globally, finding that an exorbitant 9 out of 10 projects had overrun: overruns of 50-100% were common! And overruns have been a constant problem for the 70 years of data available. To buttress this, Aziz *et al.* (2013:2621) investigated 258 projects in 20 nations with an approximate worth of US \$90 billion (project size ranging from \$1.5 million to \$8.5 billion) and discovered cost overrun was usual, again happening in almost 9 out of 10 projects, with a medium of 28% higher than forecast costs. It was concluded that average cost escalation in Europe was 25.7%, North America 23.6% and other geographical areas was 64.6%, with cost performance in construction projects showing no improvement over time. In fact, today it is in the same shocking order of magnitude as it was 70 years ago.

2.5.2 Quality consideration

Harris and McCaffer (2013) described the *quality* of a product or service to be characteristic value added by the project manager to meet the listed requirements of a customer. Rumane (2011:8) argued that construction quality not only encompasses the quality of materials used in construction works, but also incorporates the complete management approach engaged to complete a construction project, to ensure that the needs of the future generation are sustained with the available resources not being compromised. In the context of sustainable building delivery, quality management consideration remains a fundamentally prerequisite

for the production of buildings that satisfy client forecasts while reducing contingent recurring cost related to operation and maintenance (PMBOK, 2008:190).

In an effort to encourage quality of production in engineering, the International Organisation for Standards (ISO), founded in 1947 in Switzerland, was advocated and certified for management standardisation. This body has been accepted internationally for quality production legislation (Terlaak & King, 2006). It was also accepted internationally for adoption of Total Quality Management (TQM); Six Sigma; Failure Mode & Effect Analysis (FMEA) and Quality Inspection and Management (QIM) as approaches for quality building production. Furthermore, ISO combines implementation of policies, attitudes, procedures, technology, record keeping and resource management to achieve an acceptable minimum quality of production (Knutson *et al.*, 2009:506).

2.5.3 Time consideration

In the construction industry, one of the main objectives of consultants is to accomplish timely completion of projects within specified budget and at prerequisite quality (Memon *et al.*, 2011:54). Chan and Chan (2004:211) defined *construction time* as the complete time planned for a particular project, from the beginning of construction activities on site to completion of the construction project. Choudhury and Rajan (2003) stated that when determining the duration of a construction project, the size of construction team, method of construction and equipment adopted to execute a construction project should be taken into consideration for timely completion. Therefore, an effective use of time to utilize construction resources effectively with reduced materials wastage and costs aimed at stakeholder satisfaction is essential (Fapohunda & Omoniyi, 2011). Notably, stakeholder satisfaction and timely project completion has been a yardstick for measuring project success in relation to time, quality, scope and cost (Mallak, Patzak & Kurstedt, 1991; Takim, 2009; Pinder, Schmidt, & Saker, 2013). A construction project is considered 'commendably and sustainably realized' when the project is delivered on time, within cost and scope, and meets the required quality. Hence, satisfying customer expectations of time, cost, quality and scope are expedient. Figure 2.3 presents a model for continuous improvement in construction productivity to enhance timely delivery of construction projects, at budgeted costs and at the expected quality standards.

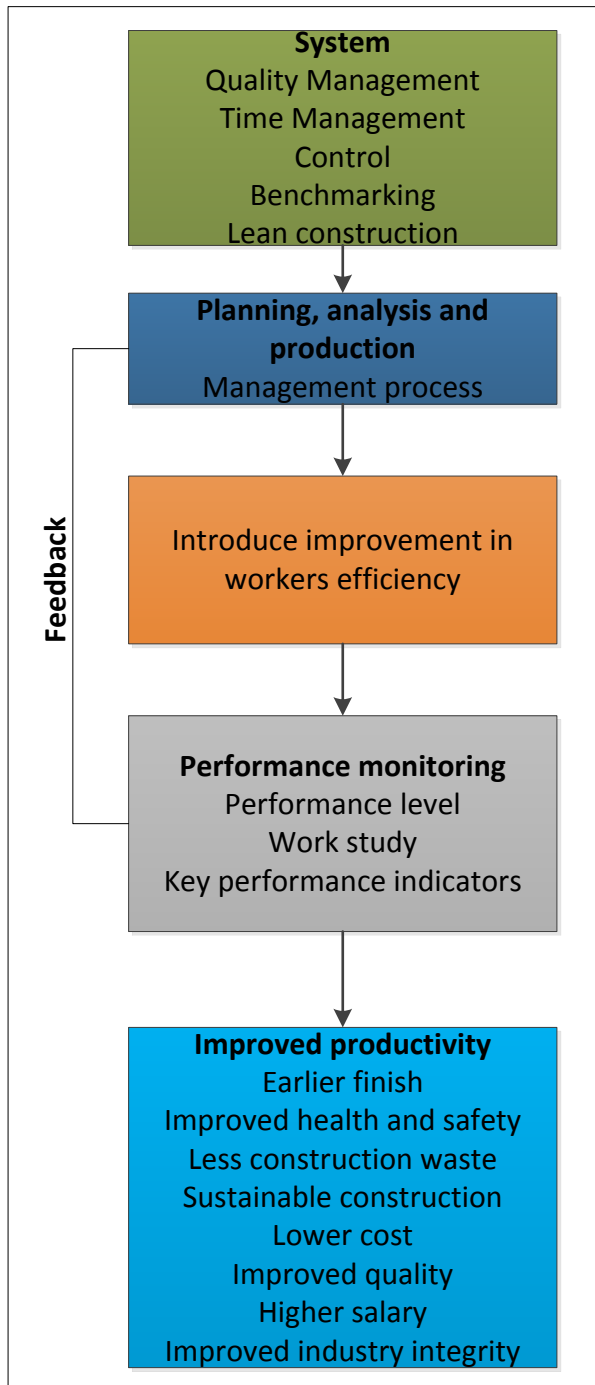


Figure 2.3: Model for continuous improvement of construction productivity

(Adapted from Harris & McCaffer, 2013:47)

2.5.4 Human management

Human resources play a significant role in construction activities (Rahman *et al.*, 2012). In fact, the importance human resources cannot be underestimated in the construction industry. Adequate application of construction materials and machinery is reliant on the effectiveness of manpower in the construction industry (Adebowale, 2014:18). However,

Rahman *et al.* (2012) indicated that effective human resource management in the construction industry will enhance productivity, reduce labour cost and maximise the profit of the construction industry. Notably, the cost-effectiveness of construction projects is dependent on the ability of supervisors to communicate effectively with workers, competently direct activities of subordinates and proper planning of construction activities (Olabosipo *et al.*, 2011:255). Adebowale (2014:19) further emphasised that excellent communication management is a main tool for improving the management of human resources in construction for enhancing the production process and delivery of project within budgeted cost.

2.6 Material management

Material management is a system of minimising waste on site, purchasing, delivering and sourcing materials with the intent of ensuring that essential requirements are met (Kasim 2011:32). Similarly, the process of material management is characterized for planning, handling and controlling all features needed to ensure that materials are available at point of use, when needed, and at sufficient quality and quantity (Rajaprabha *et al.*, 2016:1). To be succinct, the aim of material management is to ensure that construction materials are available at their point of use when needed (Patal & Vyas, 2011:1), as essential management of materials improves productivity in construction projects. Hence, the effective use and management of materials avoids delay in projects and optimizes a company's cost profitability (Rahaman & Alidrisyi, 1994:412). Hence, efficient materials management is a critical component in project management. According to Dey (2001:394), material costs constitute almost 60% of the capital of any housing industrial organization. However, early purchasing of materials not only ties capital down but also increases accumulated interest rate charges, with materials prone to deteriorate or be stolen during storage (Patel & Vyas, 2011:1). Therefore, ensuring a timely flow of materials is an important concern of material management; effective sustainable use of materials must be serious concern to project managers, as illustrated in Figure 2.4.

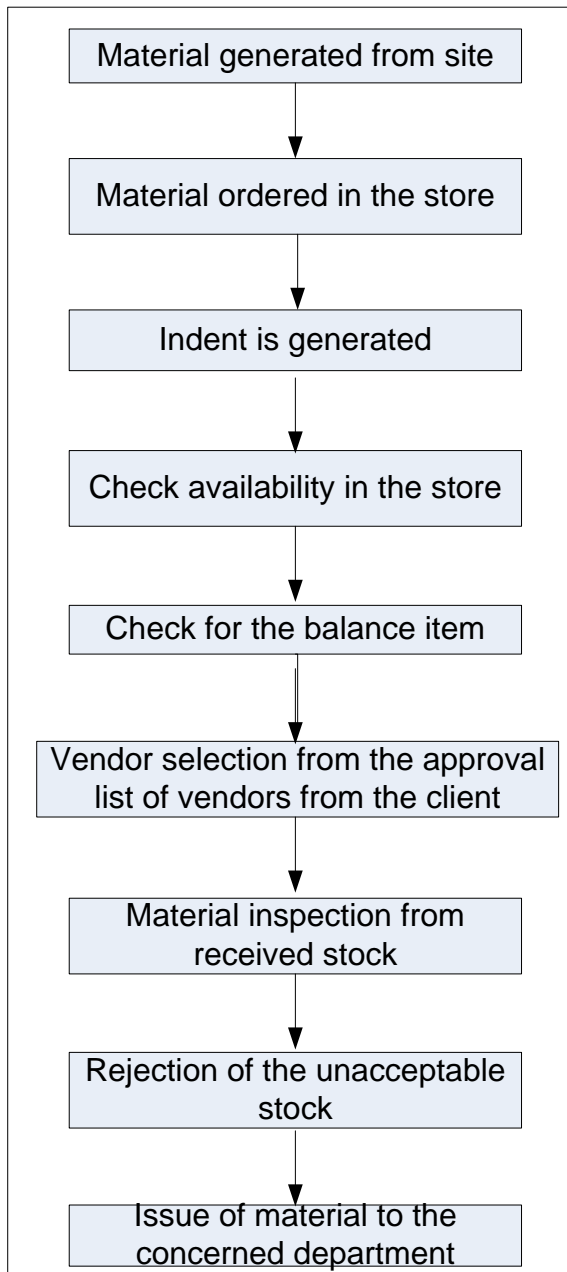


Figure 2.4: Process of material management [material flow chat]

(Adapted from Patel & Vyas, 2011:2)

To better understand material management for stakeholders, the following steps are fundamental required for effective material management during construction, as proposed by Patel and Vyas (2011:1).

- broad knowledge of material estimation, budgeting and programming;
- expansive knowledge in material scheduling, purchasing and procurement;
- skilful stocks control procedures and technique;
- good inventory control (purchase costs control, order costs and holding cost); and

- material utilization and waste management.

Effective material management will produce the expected outcome, with the right quantities of the right material at the right time (Arnold, 2004). Nevertheless, the expected outcome can still be compromised by different management problems identified amongst contractors, problems which vary in nature and impact but are usually related to inefficient management of construction resources, including materials, labour, plant and subcontractors (Chan, 2002:59). Kasim (2011:32) highlighted these problems as follows:

- late site storage facilities;
- improper material handling;
- poor general material logistics;
- poor site access points;
- operation limitations due to security consideration;
- poor material procurement strategy; and
- improper material deliveries.

Any small improper handling and managing of materials will have a massive impact on the total project cost, time and quality. Donyavi and Flanagan (2011:465) noted that in order to reduce construction cost, and thereby increase construction productivity, quality and timely project delivery, and efficient material management must be a top priority. Efficient or effective management of building materials has been identified as the easiest approach for project managers to incorporate sustainable principles into a building construction project (Akadiri & Olomolaiye, 2012:666).

2.6.1 Materials utilisation and wastage

Materials utilisation is an essential aspect of building construction which improves the attainment of sustainable structures. Yehia *et al.* (2015) revealed that current statistics indicate a high demand for construction materials: but increasing demand is accompanied by an increase of construction waste. Baloi (2003) stressed that the rate of material usage in construction has escalated shockingly due to its hostile influence on the environment. Because of this, Lu and Tam (2013) emphasized that material usage in construction requires a change in approach from a direct to a cyclic approach to achieve required sustainability.

According to USGBC (2008) strategies for material utilisation, emphasis is on the 4 Rs of sustainable construction: reducing material consumption, and the use of renewable, reusable and recyclable materials to minimise the harmful effects of construction on the

environment. Similarly, Yehia *et al.* (2015) stated that recycling has the ability to decrease the quantity of waste materials chucked into landfills and to protect natural resources. Therefore, the concept of the 4Rs approach is a dynamic law for an effective framework for material utilisation and construction waste control.

2.6.2 Waste management

Kareem and Pandey (2013:345) described *waste management* as a means of “eliminating waste wherever possible; minimising waste wherever feasible; and reusing materials which could become waste”. However, all over the world, including South Africa, construction activities contribute a considerable amount of waste generating a sizeable challenge faced by the construction industry (Kasim, 2011). Correspondingly, Gulghane *et al.* (2015:62) stressed that material waste has been acknowledged to have an effect on the productivity of the industry and environmental impact on construction projects: this is a major problem in the construction industry.

Construction wastes can be defined as materials or elements accumulated as a result of demolitions or renovations; unintended material utilisation; abandoned, processed or unprocessed surplus materials (Hong Kong Environmental Protection Department, 2010; Nagapan *et al.*, 2011). Construction waste arises from different construction activities taking place on site, such as waste from land excavation, civil and building construction materials, site clearance waste, roadwork waste and building renovation waste. This could be in form of building debris from demolition process, rubble, earth material, concrete waste, steel waste, timber waste, and mixed site clearance construction materials (Gulghane *et al.*, 2015:62).

Waste in construction could also be described as any ineffectiveness that results in the use of equipment, materials, labour or capital in larger quantities (Nagapan *et al.*, 2012:23). Therefore, waste in construction is not only concerned about the amount of waste of materials on site, but also connected to numerous undertakings such as overproduction, waiting time, material handling, processing, inventories and movement of workers (Alarcon, 1994; Formoso *et al.* 1999). Previous studies undertaken by Nagapan *et al.* (2012) highlighted 81 factors causing construction waste, clustered into seven groups of factors: design of project, handling of construction materials and equipment, construction workers, project management, site condition, procurement of materials and external factors.

Construction waste can be minimised by implementing a waste management system for the project. Then, the project activities are planned at every stage by every construction personnel involved, in minimising the overall project waste generation (Thomas *et al.*, 2013).

Waste management remains essential in the attempt to achieve sustainability. In addition, the application of the 4Rs – reduce, reuse, recycle, and recovery – to the whole life cycle of production, can lessen the wastage of building materials (Kareem *et al.*, 2013; Thomas *et al.*, 2013; Bagdi *et al.*, 2013). Efficient management of construction waste is a vital concern in project management adding to the attainment of sustainable developments and sustainable building delivery.

2.6.3 Cost overrun in construction project

Cost overrun is a major problem particularly in developing countries, where the cost overrun sometimes exceeds the estimated cost of the project (Reina & Angelo, 2002). The factor that constitutes construction cost overrun varies from one project to the other due to scope, size and complexity of the project (Kasimu, 2012:775). Koushki *et al.* (2005:285) found that contractor related problems, material related problems and owners' financial constraints were main causes of cost overrun in Kuwait's private residential projects. A survey was carried out among key stakeholders (contractors, consultants and client organisations) in Nigeria. It was found that poor planning, shortage in materials, imported materials, changes in site conditions, design changes were the main causes of construction delays and cost overrun (Mansfield *et al.*, 1994:254).

Baloyi and Bekker (2011: 55) highlighted some the factors that causes cost overrun in construction project as change in the price of construction materials, additional work and delayed constituted by contractors. Further, Kasimu (2012: 779) noted that the most significant factors that result to cost overrun in building construction are condition of the market, experience of contractor, time constraint and political situation. A study conducted by Olawale and Sun (2010: 522) relative to the construction industry in United Kingdom reveal the top five factors inhibiting time and cost control in construction practice as design changes, risks and uncertainties; inaccurate evaluation of project time/duration; complexity of works and; non-performance of subcontractors. Similarly, Al-Juwairah (1997:192) conducted a study to identify factors affecting construction cost in Saudi Arabia, 42 factors were identified in the study. The top five major factors affecting construction costs from the contractors' perspective were: cost of materials, incorrect planning, contract management, wrong estimation method, and previous experience in contract. Furthermore, Mahamid *et al.* (2012:70) conducted a survey using data from Palestinian road construction projects awarded over the years 2004 to 2008 to investigate the statistical relationship between actual and estimated cost of road construction. The survey was based on a sample of 169 road construction projects. The findings revealed that 100% of projects suffer from cost diverge, it was also found that 76% of projects have cost under estimation and 24% have

cost over estimation. The discrepancy between estimated and actual cost has an average of 14.56%, ranging from -39.3% to 98%. Consequently, the South Africa construction industry also experienced notable cost overruns in several large scale projects; Johannesburg's soccer stadium experienced a cost overrun of 58%. Notably, Greenpoint stadium in Cape Town experienced a 50% cost overrun. Durban stadium also experienced a cost overrun of 38% (Ramadodu & Verster, 2010:135). In addition, Prajapati, Gupta and Pandey (2016:1349) conducted a study to investigate the cost overrun in school building construction project. The study identified 26 factors as critical factors out of 41 cost overrun factors identified in the study. Hence, the top five factors affecting cost overrun in building construction projects are political situation, fluctuation of prices of materials, level of competitors, currency exchange, and economic instability. Nega (2008:106) noted inflation, increase in the cost of construction materials, poor planning and coordination, change orders due to enhancement required by clients, and excess quantity during construction as the most important causes of cost overrun in building construction projects in Ethiopia.

2.6.4 Time overrun in construction project

According to Kaming *et al.* (1997:83), a *time overrun* is defined as the extension of time beyond planned completion dates. However, time overruns can occur in any or all phases of a construction project thereby increasing total project duration (Yang & Ou, 2008:323). Memom *et al.* (2011:54), with a survey distributed amongst project management consultants, discovered that the dominating factors causing time overruns are cash flow and financial difficulties faced by contractors. In addition, Olawale and Sun (2010:84), in their studies of high-rise projects, found the most important factors causing time overrun to be design changes, poor labour productivity, inadequate planning and resource shortages. Further, in their study, Ade-ojo and Babalola (2013:5) identified six major causes leading to schedule overruns, ranked as follows: 1) design error; 2) poor site condition; 3) delay in payment; 4) financial incapability of client; 5) financial incapability of contractor; and finally 5) non-availability of subcontractor and supplier.

Delays are inevitable and appear in every construction project, with causes of these delays varying considerably from project to project (Koshe & Jha 2016:20). Finding from previous studies (Hanna *et al.*, 2004:763; Sambasivan & Soon, 2007:517) have shown that delay in projects has positive and linear relationship with the increase in cost. Similarly, le-Hoai *et al.* (2008:369), studying problems related to delays and cost overruns during construction phase, noted financial difficulties of owners and contractors, poor project management assistance, design changes, poor site management and supervision, and financial difficulties of contractor as the most severe, common causes identified for delays and overruns. To

buttress this, Koshe and Jha (2016:28) identified 88 major factors that cause delay in the Ethiopia construction, categorising the factors into eight major groups. Their investigation showed that contractor financial difficulty was the most influential factor causing delays in construction. Table 2.1 illustrated the factors responsible for cost and time overruns used in this research.

Table 2.1: Factors responsible for cost and time overrun

Factors	Supported by
Contractor related problems	Koshe & Jha (2016); le-Hoai <i>et al.</i> (2008); Ade-ojo & Babalola (2013); Baloyi & Bekker (2011); Olawale & Sun (2010); Kasimu (2012); Koushki <i>et al.</i> (2005); Kasimu (2012)
Design changes	le-Hoai <i>et al.</i> (2008); Ade-ojo & Babalola (2013); Nega (2008); Olawale & Sun (2010); Kaming <i>et al.</i> (1997); Mansfield <i>et al.</i> (1994)
Poor planning	Mansfield <i>et al.</i> (1994); Nega (2008); Kaming <i>et al.</i> (1997); Al-Juwairih (1997)
Fluctuation in the cost materials	Baloyi & Bekker (2011); Al-Juwairih (1997); Nega (2008); Prajapati <i>et al.</i> (2016)
Political situation	Kasimu (2012); Prajapati <i>et al.</i> (2016)
Wrong estimation	Al-Juwairih (1997), Mahamid <i>et al.</i> (2012)
Shortages of materials	Mansfield <i>et al.</i> (1994); Kaming <i>et al.</i> (1997)
Condition of the market	Kasimu (2012); Prajapati <i>et al.</i> (2016)
Financial constraint	le-Hoai <i>et al.</i> (2008); Ade-ojo & Babalola (2013); Koushki <i>et al.</i> (2005)
Additional work	Baloyi & Bekker (2011)
Change in site	Mansfield <i>et al.</i> (1994)
Time constraints	Kasimu (2012); Olawale & Sun (2010)
Contract management	Al-Juwairih (1997)
Currency exchange	Prajapati <i>et al.</i> (2016)
Economic instability	Prajapati <i>et al.</i> (2016)
Labour productivity	Kaming <i>et al.</i> (1997)

A number of studies have been conducted to investigate the effects of cost overrun in construction projects. Table 2.2 summarizes some of these effects, as presented in some previous studies.

Table 2.2: Main effects of cost overrun in construction projects through previous studies

Effects	Less profit to client	Less profit to contractor	Cash flow problem	Dispute	End user satisfaction	Abandonment
Reference						
Nega (2008:103)	✓	✓	✓	✓	✓	
Prajapati et al. (2016:1340)	✓		✓	✓		
Memon et al. (2011)			✓			
Sandasivan & Soon (2006:526)				✓		✓
Zainuddeen et al. (2008:9)		✓	✓			

2.7 EFFECTS OF BUILDING MATERIALS COST ON HOUSING DELIVERY

In South Africa, the cause of increase in the cost of building materials resulted from the combined effects of high energy cost, exchange rate, crude oil prices and imported duties (Windapo & Cattell 2012:192). Jagboro and Owoeye (2004:11) and Aibinu and Jagboro (2002:594) noted that increase in the cost of building materials has significant effects on the industry as it leads to fluctuation in construction costs and the eventual abandonment of projects. Similarly, Windapo and Cattell (2013:70) highlighted the effects that increases in the cost of building material have on the construction industry: inability of developers to deliver affordable housing, high tender valuations and poor construction industry performance. Akanni et al. (2014) identified some possible effects that increase in the cost of building materials have on delivery of housing: completion at the expense of other projects; delay in progress of project works; other valuable projects not being commissioned; rate of unemployment of construction workers; poor workmanship due to inadequate materials to use; low quality local materials; and hindered implementation of innovation in construction.

2.7.1 Fluctuation in cost of construction

According to Windapo and Cattell (2013:70), substantial growth in the construction industry is subject to price stability in materials costs as these have increased at faster rates than the

expected. Client and project contractors have been facing serious issues to maintain steady cost projection on construction projects (Akanni *et al.*, 2014:2). According to Ali and Kamaruzzaman (2010:116), poor estimation of original project cost and underestimating the construction cost by quantity surveyors are the basic reasons of cost escalation in construction industry. The researcher further stated that the prices change so quickly that the initial budget figures become completely unrealistic. Akanni *et al.* (2014:6), in their study of the implications of the rising cost of building materials in Nigeria, determined fluctuation in construction costs as the most significant effect of increase in the cost building materials. This is in agreement with Windapo and Cattell (2013:75) who found, on the key issue affecting the development of the construction industry in South Africa that increase in costs of building materials was a significant factor affecting development of the construction industry. This can be attributed to inflation. Inflation in the cost of building materials has resulted in low and unreliable rates of profitability, having a detrimental effect on performance of the industry in the area of innovations in construction methods and material research, thereby hindering delivery for sustainable housing.

2.7.2 Increase in project abandonment.

Haseeb *et al.* (2011:35) referred to the total abandonment of a construction project as stopping every work or suspending the project for a long time. Numerous construction projects are temporarily or even permanently abandoned, and according to Haseeb *et al.* (2011:35), the predominance of many uncompleted and abandoned projects resulted from finance related crises and material related factors. Ayodele and Alabi (2011: 144) and Idoro and Jolaiya (2010) identified inflation and high cost of building materials as major factors that lead to uncompleted and sub-standard buildings. The researchers further affirmed that this has a significant effect on the industry for delivery of housing. Whereas Aluko (2008:20) stated the effects of abandoned project on environment and identified such effects as the problems of flooding, traffic congestion, air and water pollution, drug addiction and health hazards in the neighbourhood, a later study conducted by Akanni *et al.* (2014:5) revealed that an upward review of contract sum leads to conflicts between contractors and clients, likely leading to cases of abandonment where investments are tied down, since such project will not be put to use at the expected time.

2.7.3 Low volume of construction product

Output of the construction industry in South Africa is quite low when compared with the construction industry in many developed countries. Ganiyu (2016:27) stated that the South African construction industry is faced with a number of threats, primarily affecting its performance in sustainable housing delivery. Similarly, in the studies of Windapo *et al.*

(2004:640), in Nigeria millions of middle and low-income families are being priced out of the market for home ownership due to this excessive increase in the cost of building materials and the consequential acute shortages of housing. The observations from these studies were due to the increase in the cost of building materials. Anosike (2009:38) confirmed that Nigeria has more than 17 million in housing deficit as of 2004.

2.7.4 Poor quality of workmanship

According to Lam, Chan, Wong and Wong (2007) output of quality buildings and structures is one of the attributes of a developed construction industry. The quality of workmanship in construction work is assessed according to the requirement of the relevant standard, and marks are awarded if the workmanship complies with this standard (CIDB, 2011). The study of Oladipo and Oni (2012), reporting the trend in the cost of building materials, has envisaged great danger for the construction industry and the nation's economy. The researchers further claimed that there were records of conflicts between clients and building contractors over review in contract sums, so to avoid conflicts and still be in the business, some contractors fell back upon substandard or insufficient materials for construction projects, an action which contributed to cases of building collapse. Undeniably, workmanship plays an important role in project quality (Iwaro & Mwashu, 2012). Akanni *et al.* (2014:6) further revealed low quality workmanship and inhibited innovations in construction methods as further repercussions of building materials cost increases. Hence, the studies revealed that increases in the cost of building materials contribute to low and unreliable rates of profitability of contractors as attempts to balance up by enticing contractors to employ low quality workmanship, prohibiting new innovations in the construction methods.

2.7.5 Unemployment of construction workers

Construction industry workers are extremely varied, as the industry is comprised of a wide range of both skilled and unskilled workers (Akanni *et al.*, 2014). Ayodele and Alabi (2011) found that inflation in the cost of building material is killing the construction industry as many contractors are unable to accurately forecast expected profit on the project, a situation that has contributed to laying-off of workers and closure of firms in some extreme cases. Oladipo and Oni (2012:133) supported this notion by stating that macro-economic indicators have an effect on the cost of building materials which has contributed to unemployment. Akanni *et al.* (2014:6) also revealed that reduction in the employment of labour workers in the construction industry is most likely to impact the nation's gross domestic product (GDP), thereby reducing the contributions of the construction industry to the nation's economy.

2.8 Selection of sustainable building materials

Building and construction activities worldwide consume three billion tons of raw materials each year and represent 40% of total global use (Hamner, 2007:25). Sustainability goals may be achieved by considering factors such as environmental impact, economic impact, customer requirements and market demand (Ljungberg, 2007:466). However, building materials are usually selected through functional, technical and financial requirements. Therefore, to achieve economic benefits in the construction industry, it is essential to note that a building is characterized by the materials used in its construction and should be selected in conformity with principles of sustainability (Abeyundara, Babel, & Gheewala, 2009:998). Conversely, an inappropriate selection of materials may prohibit the accomplishment of the desired sustainability goals (Florez *et al.*, 2010:1). In fact, an appropriate approach of selecting sustainable materials has been identified as the easiest way for designers to begin incorporating sustainable principles in building projects (Godfaurd *et al.*, 2005:34). The environmental impact of materials needs to be carefully evaluated for developing sustainable materials. The Life Cycle Assessment (LCA) method is a common technique for evaluating environmental impact associated with material products (Bovea & Gallardo, 2006:209) as it takes into consideration all the phases of a product's life cycle.

Life cycle assessment ratings at each phase of building are essential for building sustainability (Ljungberg, 2007; Karana *et al.*, 2010). The Life cycle design principle is a platform for the selection of building materials, encompassing the manufacturing process, installation and even end use and disposal are inspected for environmental impact. According to Kim and Rigdom (1998:7) material life cycle is divided into three phases:

- the pre-building phase;
- the building phase; and
- the post-building phase.

The pre-building phase encompasses the discovering, manufacturing and delivering as well transporting of materials needed for construction to the point of use. This phase is critical and thus must be intentionally selected due to its strong impact on the environment (Kim & Rigdom, 1998:7). Therefore, full knowledge of environmental consequence of this phase is required in order to select the best building materials for construction. If this phase is not well managed during extraction, a negative impact on the environment is likely (Ljungberg, 2007:466).

The building phase describes the usefulness of building materials in a building. This phase comprises construction and maintenance of materials; waste generated during construction can be recycled (Kim & Rigdon, 1998:11). The post-building phase results from decisions made during the building phase in terms of waste disposal (recycling or reusing). These phases are likely to be sustainable (Ljungberg, 2007:466). Figure 2.5 illustrates the procession of the phases of building.

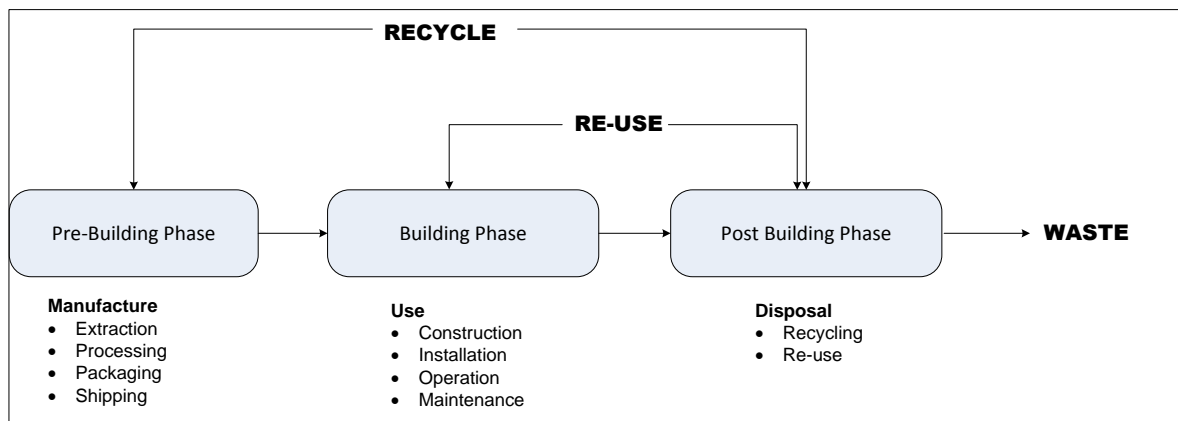


Figure 2.5: The building materials life cycle phases

(Adapted from Kim & Rigdon, 1998:8)

In order to attain sustainability in building and stakeholder satisfaction, the process of discovering raw materials as well as extracting materials, processing and usage are essential (Florez, Castro & Irizarry, 2010:2). Moreover, the durability and functionality (aesthetics, health enhancement, use of space) of the building depends on adequate use of quality building materials (Karana, Hekkert & Kandachar, 2010:2933). Thus, the materials selection phase is vital and should be adopted during construction.

2. 8.1 Principles of material selection towards sustainable construction

Material selection in sustainable building production is defined as the process of choosing materials that suit the design criteria such as function, shape, cost and cultural aspects of the building (Karana *et al.*, 2010:2932). According to Alibaba (2004:307) and Nasar *et al.* (2003:543), one of many factors that impact the sustainability of building delivery is selection of building materials. Notably, material selection could be done in different ways, but the principles are similar. Kibert (2012:7), for example, posited some principles to achieve sustainability in a project as guidelines for materials selection:

- environmental impact;
- market demands/ trend;
- material life cycle cost;

- functional and structural demands;
- dematerialization in design;
- socio-economic impact;
- material efficiency (use of renewable and recyclable materials);
- building design; and
- technological impact.

Lyungberg (2007:469) also highlighted some guidelines for material selection: material overview, recycling, market aspect, customer demand and dematerialization. In addition, Baharetha *et al.* (2012:732) claimed the attributes that designer should incorporate when selecting sustainable materials include durability, recyclability, energy efficiency maintainability, and use of locally made materials to lessen the deleterious environmental consequences on construction. This cannot be done without carefully understanding the scope, nature and complexity of a construction project. Furthermore, Abeysundara *et al.* (2009:999) listed functionality, social issues, cost, aesthetics, density, temperature stability, material strength and durability as important factors that influence the selection of materials. Clearly, the selection of materials at the early stage will enable designers to uphold functional requirements of a building using the best available materials and to develop a feasible plan for achieving the specified design and structure (Deng & Edwards, 2007:131; Rao, 2008:1949).

Zhou *et al.* (2009:1209) posited some factors to be incorporated by designers when selecting a material in Figure 2.6, the designer must consider fulfilling the three basic properties: mechanical properties, economic properties and environmental properties. According to these researchers, economic property is the most important aspect in material selection. Purchase cost, process cost, transportation cost and recycle/disposal cost are the four factors considered under economic property. Additionally, mechanical properties are especially important because they are indicators of strength, density, stiffness, and hardness. And finally environmental property should not be neglected for the consideration in the selection of sustainable building materials.

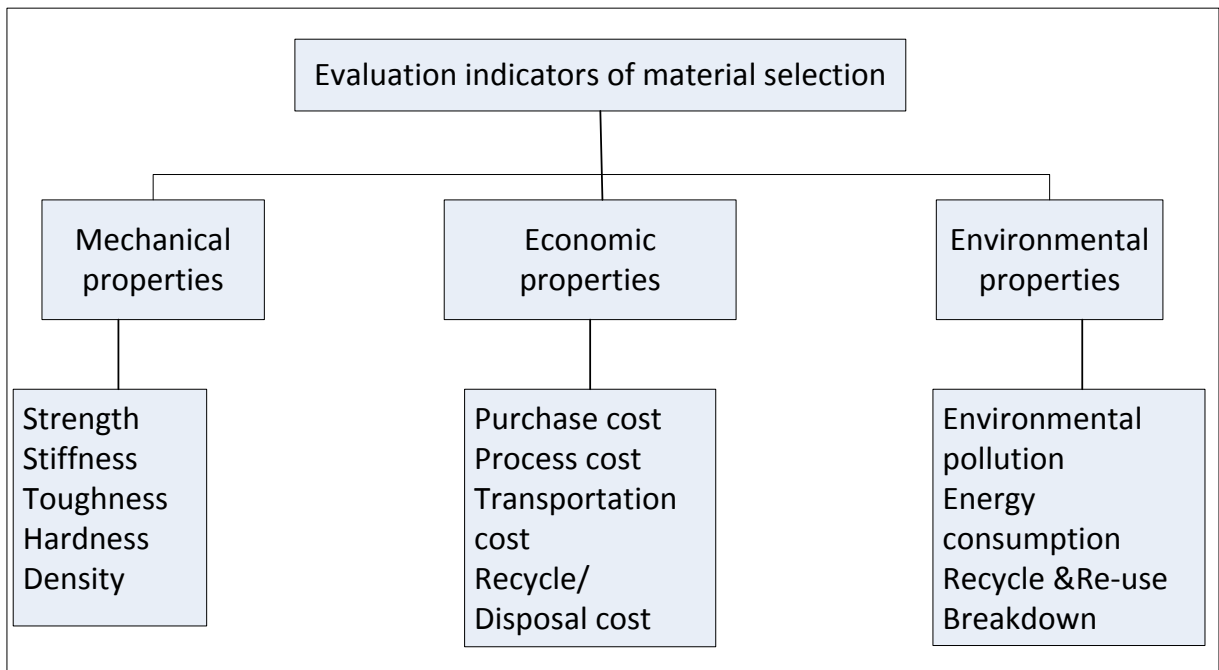


Figure 2.6: Evaluation indicators of material selection

(Adapted from Zhou *et al.*, 2009:1210)

2.8.2 Criteria for selection of sustainable building materials

In deciding the type of building material to use in a particular application, it is vital to know the criteria for selecting such materials (Akadiri & Omolaiye, 2012:671). Basically, with the growing number of building materials available, each has specific functional demands and complex assembly requirements for building construction (Sharma & Mehta, 2014: 81). Building construction is a major contributor to greenhouse gas emissions and global ecological degradation. Hence, in order to sustain the urban future and to prevent environmental damage, protect natural resources and improve the health of ecosystems, a wise choice of materials is imperative (Sharma & Mehta, 2014:80). The overall method for selecting building materials can be broadly divided into five categories (Froeschle, 1999):

- resource efficiency;
- energy efficiency;
- water conservation;
- indoor air quality; and
- affordability.

2.8.2.1 Resource efficiency

Resource efficiency simply means the efficient use of materials, energy and natural resources so as to produce materials with reduced resources and environmental impact (Ruska & Häkkinen, 2014:267). Notably, Abeyundara *et al.* (2009) emphasised that the selection of materials should be based on the environmental impact of the materials, and this should be incorporated at project initiation and design phases. According to Sharma and Mehta (2014:82), resource efficiency can be made proficient by using material that run into one or more of the following criteria: recycled content, naturally plentiful or renewable, resource efficient, locally available, salvaged, refurbished, or remanufactured, and certainly durable. Akadiri (2011:115) stated that the significance of reusing and recycling the building parts is the saving energy. He further verified using recycled materials to produce new building materials consumes less energy than using new materials. The reuse of building materials is a substitute for the reduction of construction and demolition waste (CDW) when renovating and demolishing building (Da Rocha & Sattler, 2009). Therefore, reuse and recycling appears to be an approach worthy of consideration for embracing sustainable practices, as it contributes significantly to waste reduction in the building process.

Natural materials usually have less embodied energy and toxicity than artificial materials (Godfaurd *et al.*, 2005). The use of sourced locally building materials can help to reduce environmental damages, reduce air pollution and reduce transport distances (Akadiri, 2011:117). Combining natural materials into building products increases the sustainability of the products (Godfaurd *et al.*, 2005).

Increasing material durability will also improve the sustainability of a building (Akadiri, 2011:116). The more durable the material is, the less time and fewer resources required to maintain it. Over the building's lifespan, a less often replaced durable material requires smaller amounts of raw material and will produce less landfill waste (Akadiri *et al.*, 2012).

2.8.2.2 Energy efficiency

Energy efficiency is an important feature in enhancing the environmental sustainability of materials (Arora, 2009). Thus, major aim of using energy efficient materials is to lessen the amount of generated energy in a building. Energy efficiency can be best realised by using materials, components and systems that lessen energy intake in buildings and facilities (Sharma & Mehta, 2014:82).

2.8.2.3 Indoor Air Quality (IAQ)

In order to meet the needs of the present without compromising the ability of future generations to meet their own needs, taking cognizance of the quality of air we breathe inside the building has gained considerable attention over recent decades (Niu & Burnett 2001). Materials applied in the interior of a building can be source of pollutants, significantly affecting the indoor air quality which in turn is harmful to the health and comfort of building occupants (Arora, 2009). According to Mehta & Sharma (2014:82), indoor air quality can be improved by using materials that adhere to the following criteria: low or non-toxic, minimal chemical emissions, low-voc assembly and moisture resistant.

2.8.2.4 Water conservation

Materials that have water conservation features help in reducing the amount of water used on site. In addition, water consumption can be monitored and capped in buildings and landscaped areas by making use of products, materials and systems that reduce water consumption as well as increasing water recycling and reuse (Sharma & Mehta 2014:82). Kim and Rigdon (1998) highlighted examples of ways by which water can be conserved, by controlling the amount of water through a fixture and recycling water that has previously reached the site or been used. Thus, recycled gray water from sinks, showers and laundry can be re-designated to flush toilets. Using water resourcefully and reducing the amount of water used will aid in the much-needed conservation of freshwater (Arora, 2009:36).

2.8.2.5 Affordability

Sustainable building materials are said to be affordable when less costly than counterpart conventional building materials or within budgeted construction cost as well as low life cycle cost (Mehta 2015). Cost related with energy, replacement and maintenance costs are significantly reduced with the adoption of LCC and essential application of green construction practices (Shannon *et al.*, 2005). The LCC method is mainly applicable in determining the cost of a building which is economically reasonable with reduced use cost when compared with another building which has lower initial cost but greater use cost in terms of maintenance, operating, replacement and repair (Arora, 2009:38).

2.8.3 Cost efficiency

The theory of sustainability in regard to construction of buildings relates to the effectiveness cost and to reducing investment costs (Akadiri *et al.*, 2012). Client demand on standard quality, lower cost and timely delivery of project has been a considerable problem within the construction industry. In order to meet client demand, secure better contract and investment

return, construction stakeholders should adopt cost efficiency strategies (Dzeng & Wu, 2012). Collectively, owner, user and societal concern is primarily on the enhancement of cost efficiency of the building structures Akadiri (2011). Thus, the researcher explains the application of life cycle cost (LCC) as an important measure for carrying the client alongside at early design stage. Castillo and Chung (2004) similarly stressed that the life cycle cost of a building consists of maintenance, energy and repair costs. Akadiri (2011) revealed that measuring the importance of sustainable construction from a cost viewpoint requires more than usual life cycle costs and include usage costs and consideration of all stakeholder costs.

2.9 Chapter summary

This chapter presents reviewed literature on identified factors responsible for increase in the cost of building materials. Literature revealed the impact of several factors – economic related factors, building production related factors, stakeholder related factors and external related factors – on the cost of building materials. The literature review revealed the effects of increase in the cost of building materials on housing delivery. Consequently, this chapter encapsulates criteria to be considered in the selection of sustainable building materials. In an attempt to proffer solutions to these challenges, literature revealed that in regard to those factors responsible for increase in building material cost, there is a clear need for appropriate policy legislation by government. Securing reduced material cost at optimum quality and time towards client satisfaction is considered a necessary major focus of the construction industry.

CHAPTER THREE

RESEARCH METHODOLOGY AND DESIGN

3.1 INTRODUCTION

The impact of research method on the outcome of any research work cannot be overemphasized. The earlier chapter provided a review of existing literature in line with research objectives towards achieving the goal, the aims and objectives, of this present research. According to Dahllerg and McCaig (2004:64), *research methodology* is an approach undertaken in research in line with an extension of aims and objectives of research. Thus, the research methodology segment is a podium for researchers to validate their research method decisions in achieving the research objectives by way of answering the research questions.

This chapter discusses the various types of research methods and specific research design adopted for this study. The research instruments, designed to achieve the research objectives, are ultimately to proffer solutions to the research questions highlighted in Chapter One of this study. Thus, this chapter comprises research approaches, design, sampling techniques, data collection scheme, techniques adopted for data analysis, and essentially the test of validity and reliability of the research instrument.

3.2 Research philosophies

Full knowledge of the research philosophies that underpin various principles of research is important for researchers. Hence, Easterby-Smith *et al.* (2012:17) highlighted three imperative factors of philosophical issues in research:

- It helps researcher recognize and create design that may be outside the researcher's previous knowledge.
- Knowledge of philosophy helps the researcher to identify which design will work and which will not work.
- It helps to explain research design.

Solanke (2015:95) is of the opinion that the philosophical stance of a research study guides and validates the researcher's verdicts. Thus, his philosophical pillars of research include the following:

- positivism (realist); and
- interpretivism.

3.2.1 Positivism

Positivism is attained by the ability of a researcher to test hypotheses derived from obtainable theories by observations or measurements of social realities (Flowers, 2009). Additionally, *positivism* is a term used to refer to the quantitative nature of a research (Biggam, 2011). Thus, positivism favours a quantitative approach, relying primarily on experiment, survey, questionnaire for data collection and analytical statistical analysis. The qualitative approach would not fit easily within the positivist approach to research. The view of positivism maintains that objects of social sciences, namely people, are suitable for the implementation of scientific methods. Similarly, Henn *et al.* (2006:6) connects positivism straight to the scientific model. Furthermore, the researchers stated the logic of positivist research philosophy as follows:

- knowledge centred on what can be verified by scrutiny of tangible evidence;
- seeks to identify processes of cause and effect of phenomena to test theory;
- use of scientific method that stresses control, objectivity and standardization.

3.2.2. Interpretivism

Interpretivism is a method that aims to understand people (Babbie & Mouton, 2005). The interpretivism paradigm of research is concerned with the use of unstructured qualitative approaches in the collection of data, including comprehensive interviews with participants (Henn *et al.*, 2006:14). Thus, the fundamental idea of the interpretivism paradigm in research is to work with subjective meaning already in the social world by exploring the complexity of social phenomena, avoiding distortion, gaining understanding as well as incorporating block theory in a building (Goldkuhl, 2012:5).

The interpretivist philosophy of research is based on four assumptions, as identified by Burr (2003):

- It presents a critical stance and scrutiny on hidden, forgotten or undiscovered knowledge (objective information).
- The languages used for data interpretation are derived from social interaction with the participants in a particular place and time.
- The knowledge derived is sustained by qualitative methods and social relations with participants.

- Subjective knowledge and social processes and actions are relative.

3.3 Research methodology

Mouton (2001:56) views *research methodology* as concentrating on the research process and the type of tools and procedures to be applied. Similarly, Leedy and Ormrod (2010) described *research methodology* as a step-by-step process of conducting a research in a particular study. Furthermore, the researchers specified the primary purposes of the research methodology as follows:

- to set a standard for data acquisition; and
- to collate the data after acquisition and give interpretation.

3.3.1 Quantitative research method

Creswell (2009:146) defined *quantitative research* as 'an inquiry into a social or human problem, based on testing a hypothesis or theory composed of variables, measured with numbers, and analysed with statistical procedure to determine whether the hypothesis or theory hold true'. Furthermore, quantitative research is a logical process of using numerical data from a designated sample group of a population to generalize the findings to the population of study (Maree & Pieterse 2007). Hence, the process of the quantitative research method involves clearly stating and presenting research questions to respondents designed to answer the research objectives (Dahlberg & McCaig 2010:159). To that end, Maree and Pieterse (2007) and Flick (2015) explained that this research method is characterized by three elements:

- objectivity;
- numerical results(data); and
- generalisability.

Akadiri (2011:173) identified the three types of quantitative research as experiments, quasi-experiments and surveys. The nature of the research depends mainly on types of techniques selected. The survey technique is the most widely used method in social science and also the most relevant to this study. Typically, the quantitative method makes use of a questionnaire. Quantitative research always involves the numerical analysis of data gathered by means of some kind of structured questionnaire. The most common of this technique are mail (use of online Survey Monkey), personal and telephone survey (Rubin & Babbie, 2010; Creswell

2009:148). Table 3.1 collates the advantages and disadvantages of these three data collection methods.

Table 3.1 Advantages and disadvantages of survey methods

Types of Survey	Advantages	Disadvantages
Mail survey	<ul style="list-style-type: none"> • Cost is low compared to other methods • High degree of respondent anonymity • Wide geographical reach • Relatively low cost of processing 	<ul style="list-style-type: none"> • Low rates of response • Require easily understood questions and instructions • Lack of chance to probe for further or clarity of answers • Greater respondent bias • High rate of uncompleted questions
Personal survey	<ul style="list-style-type: none"> • Allows high flexibility in the questioning process • Interviewers have control of interviewing situation • High response rate • Possibility of collecting supplementary information 	<ul style="list-style-type: none"> • Higher cost than mail questionnaire • Potential interviewer bias due to high flexibility • Lack of anonymity; hesitant to disclose personal data • Time consuming
Telephone survey	<ul style="list-style-type: none"> • Moderate cost • Increased speed and time of data collection • High response rate • Increased quality of data 	<ul style="list-style-type: none"> • Hesitancy to discuss sensitive data on phone • High chance of respondents terminating interview earlier • Less chance for supplement information

(Adapted from Rubin & Babbie, 2010)

3.3.2 Qualitative research

Qualitative research method deals with the technique for exploring and understanding the meaning of individuals or groups ascribe to a social or human problem (Olayinka, 2015:150). In addition, the qualitative research method involves the effort of collecting in-depth descriptive data concerning a particular phenomenon with the purpose of improving knowledge (O’leary, 2010:105). Furthermore, Amaratunga *et al.* (2002:20) stress that qualitative researchers investigate the opinions, beliefs, understandings and views of the respondents, and to this end, the qualitative research method includes the use and collection of various empirical data: an interview, life story, observations and historical studies (Creswell & Clark 2007).

There are several advantages and disadvantages involved in using a qualitative research method. Flick (2015:12) and Kumar (2011:114) listed a few examples of advantages:

- It allows for detailed and exact analysis of a few case in which participants have much more freedom to determine issues that are relevant in the context.
- The main strength of qualitative research is the ability to study phenomena not available elsewhere.

Fellow and Liu (2008:27), Flick (2015) and Bryman (2012:382) presented the disadvantages qualitative research: it takes a great deal of time to collect data and the analysis requires some degree of interpretation, which may be subject to bias and personal subjectivity; and that a variety of external environmental variables are likely to impact the data and the results. A comparison of both qualitative and quantitative research epistemology are shown in Table 3.2

Table 3.2: Comparison between qualitative and quantitative research

Point of comparison	Qualitative research	Quantitative research
Alternative labels	Constructivist, naturalistic-ethnographic or interpretative	Positivist, rationalistic or Functionalist
Scientific Explanation	Inductive in nature	Deductive
Data classification	Subjective	Objective
Objective/ purpose	To gain understanding of underlying reasons and motivations To provide insight into the settings of a problem, generating ideas and /or hypothesis for later quantitative research To uncover prevalent trends in thought and opinion	To quantify data and generalise results from a sample to the population of interest. To measure the incidence of Various views and options in a chosen sample
Sample	Usually a small number of non-representative cases Respondents selected to fulfil a given quota or requirement	Usually a large number of cases representing the population of interest. Randomly selected respondents
Data collection	Participant observation, semi and unstructured interviews, focus groups, conversation and discourse analysis.	Structured interview, self administered questionnaires, experiments, structured observation, content analysis / Statistical analysis

Data analysis	Non-statistical	Statistical usually in the form of tabulations Findings are conclusive and usually descriptive in nature
Outcome	Exploratory and / or investigative. Findings are not conclusive and cannot be used to make generalisations	Used to recommend a final course of action

(Source: Amaratunga *et al.*, 2002:20)

3.3.3 Mixed method research

Mixed method research involves the adoption of philosophical assumptions in the collection and analysis of both quantitative and qualitative data in a single research work (Creswell & Clark 2007:114). In other words, mixed method research combines or mixes quantitative and qualitative research in the same study or series of studies in collection of data, analysis and inferences (Swanson & Holton, 2005; Johnson, Onwuegbuzie & Turner, 2007:123; Teddlie & Tashakkori, 2009:4). The fundamental notion is that the combination of qualitative and quantitative approaches provides a broader understanding of a research problem than either approach alone (Olayinka, 2015:158). Hence, mixed methods help to highlight differences and similarities between specific features of phenomena. Researchers adopt mixed methodological approach with the interest of combining qualitative and quantitative research pragmatically, mainly to compensate the paradigm shortcomings in the two approaches separately (Flick, 2015).

The merits of integrating the qualitative and quantitative method postulated by Eaterby-Smith *et al.* (2012:63) are listed in section 3.3. However, despite the advantages of the mixed method research, researchers are faced with some challenges in the course of their research. These challenges, according to Eaterby-Smith *et al.* (2012:63), are detailed in Table 3.3.

Table 3.3 Strengths and challenges of mixed methods

Strengths	Challenges
<ul style="list-style-type: none"> • Increased confidence and credibility of results • Increased validity • Stimulate creative and inventive methods • Can help synthesis and integration of theories • May serve as critical test of competing theories • Can combine confirmatory and exploratory research simultaneously • Presents greater diversity of views • Provides better inferences 	<ul style="list-style-type: none"> • Replication is difficult to achieve • Research design must be relevant to research question • They provide no help if the research ask the wrong questions • They require more resources than single method studies • Their use requires a competent overall design • Researcher needs to be skilled in the use of both methods • It is not helpful if one method simply provides window dressing for the other

(Adapted from Eaterby-Smith *et al.*, 2012:63)

3.4 Research approach

3.4.1 Deductive approach

The *deductive approach* tests the validity of assumptions (or theories/hypotheses) on hand (Bryman & Bell, 2015:27). According to Dahlberg and McCaig (2010:20), the deductive research approach involves the process of generating hypotheses from a general truth or statement to reach a definite conclusion. Therefore, a deductive approach to research consists of logical arguments which originate with general statements with the purpose of obtaining a particular conclusion (Solanke, 2015:97). The deductive research approach is principally used in quantitative research (Bryman, 2004:20).

3.4.2 Inductive approach

The *inductive approach* involves the process of beginning with a particular observation or finding and thereafter general conclusions are derived as results (Walliman, 2012). Hence, this is a 'bottom up' research approach, contributing to comprehension of reality first and ultimately producing a theory (Dahlberg & McCaig, 2010:20). The inductive approach is mostly used for scientific research. Notably, the process of induction involves drawing generalisable inferences out of observations (Bryman 2012:26). Figure 3.1 endeavours to capture the core difference between the *inductive* and *deductive* approaches.

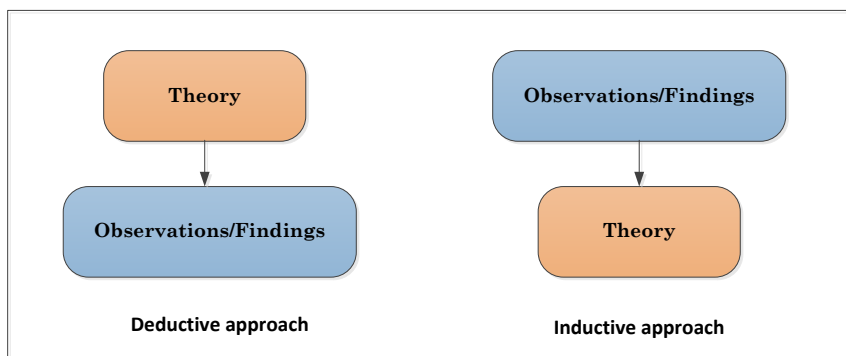


Figure 3.1 Deductive and inductive research approaches

(Source: Bryman, 2012)

Walliman, (2005) further clarified that an inductive (generalized) result can only be regarded legit if it satisfies the following conditions:

- a large size of population for survey or observation is used;
- the observation or survey is coordinated repeatedly under different conditions; and
- the derived observed empirical data corresponds with the generalized result.

3.5 Research strategies

Findings from previous studies (Walliman, 2012; Leedy & Ormrod, 2010; Walliman, 2005) showed various research strategies for the usage of qualitative, quantitative and mixed research methods. Research strategies include case studies, structured interviews, phenomenological studies, historical research, action research, experimental studies, quasi-experimental studies and theoretical research studies (Bryman, 2012; Biggam, 2015; Walliman, 2012; Leedy & Ormrod, 2010; Creswell *et al.*, 2007).

3.5.1 Survey research

O’Leary (2010:181) defined *survey research* as “the process of data collection by asking a selected set of individuals the same questions based on their characteristics, attitude and ways of living by administering questionnaires”. Thus, survey research serves as an efficient and effective means of looking at a far greater number of variables than possible as compared with experimental approaches, and is one of the most commonly used methods in social sciences to provide a descriptive sample of the area of study (Akadiri, 2011:181). Moreover, Cohen, Manion and Morrison (2001) and Henn *et al.* (2006:126) articulated that the basic aim of the survey research is to “explore, understand and interpret phenomenon(s)

which exists presently”. Therefore, survey research involves drawing information from respondents which can be achieved through questionnaires or structured interviews for data collection, with the aim of generalizing from a sample to a population (Babbie, 1990; Creswell, 2009). Maree and Pieterse (2007) enumerated the following as characteristics of survey research:

- large sample size;
- numerous variables measured to generate related hypothesis for testing; and
- results that can be generalised.

3.5.2 Action research

McNiff and Whitehead (2011:8) describe *action research* as “a form of enquiry that enables practitioners in every job and work of life to investigate and evaluate their work”. Kumar (2011:131) states that most action research is directed towards improving quality of service by identifying areas of interest, developing, testing alternatives and experimenting with a new approach. Notably, to effectively conduct action research, the researcher must possess the ability to understand and interpret the problems faced in order to offer possible and practical solutions (Kumar, 2011:132). Thus, action research, according to Ferreira (2007:124), is characterised by the following;

- It seeks to derive solutions to practical issues.
- It is aimed at effecting a change.
- It is an interactive strategy to knowledge development.
- It is a cyclic research process of planning, solution implementing and reasoning.
- It requires the participation of the research sample and the researcher(s).

3.5.3 Case study

Case study research is concerned with the complexity and particular nature of the case in question (Bryman, 2012:66). Similarly, *case study* research refers to units of investigation that are studied at different levels, such as individuals within a community, a group of people, an organisation or a phenomenon (Henn *et al.*, 2006:58). Barbour (2008:61) expresses the advantage of adopting single case study is that there is a possibility of closely scrutinising the case under study. Thus, case study research involves the study of a single case, documentation, interviews, comparative studies (multiplicity of cases) or retrospective studies using historical sources (Flick, 2011:70).

3.5.4 Historical research

Maree and Pieterse (2007) defined *historic research* as a systematic holistic process of describing, analysing and interpreting past scenarios based on information derived from a selected population. Similarly, Leedy and Ormrod (2010) defined *historical research* as an effort undertaken by a researcher to interpret historic events through the collection and analysis of relevant historic documents or oral histories. Therefore, historic research calls for the researcher to give critical, analytical scrutiny of reports, documents or minutes about an event or incident (Nieuwenhuis, 2007). Nieuwenhuis broadly enumerated four types of historic research useful in general research:

- primary sources (achieved documents or other original sources);
- secondary sources (works of other scholars on the focus of study);
- running records (documentaries maintained by organisations); and
- recollection (including oral histories and autobiographies).

3.6 Questionnaire development

A questionnaire is a tool for data collection containing questions and statements prepared to acquire information from research respondents (Adler & Clark, 2008:216). Moreover, a questionnaire survey is one of the most cost effective ways to involve a large number of people in a research process to accomplish more thorough results (McQueen & Knussen, 2002). Poorly designed questionnaires generate only unsatisfactory or inadequate data that cannot be properly interpreted (Dahlberg & McCaig, 2010:179). This necessitates the need for certain precautions to be taken into consideration when designing questionnaires: the questions must be clear and easily understood by the respondents; it should be easy to administer by the interviewer; the recorded answers should be easily edited, coded and transferred onto a computer file for statistical analysis; and its flow, length and structure must motivate respondents to complete the questionnaire (Akadiri, 2011:182). Akadiri stated that questionnaires are of various forms, but mainly divided into two categories:

- open-ended questions (respondents record their views and opinion in full); and
- Closed-ended questions (respondents choose from a given set of answers).

3.6.1 Open-ended questions

Open-ended questions are a form of questionnaire that does not give any particular guide to likely responses. Thus, the respondents are allowed to record their opinion to a particular question in their own words (Kumar, 2011:151). Open-ended questions are suitable and

appropriate for a study, for example, that plans to explore the way respondents think, and discover what is really important to respondents with the asking of questions which have many possible answers (Neuman, 2000:260). The following, according to Maree and Pieterse (2007) and Leedy and Ormrod (2010), are advantages and disadvantages of open-ended questions:

Advantages

- Participants respond to questions honestly, assured of being anonymous.
- Respondents' opinions are clearly revealed.
- Complex questions are duly answered with detailed justifications.

Disadvantages

- Data coding poses to be difficult.
- A great deal of time is required for the respondents to complete (thinking and writing).
- Answers are variable in content as a result of unstructured nature of questions.
- The use of statistical analysis in this design has proven abortive.

3.6.2 Closed-ended questions

Closed-ended questionnaires offer a set of sequential questions, requesting respondents to choose the most appropriate answers (Maree & Pieterse, 2007). Burns (2000:572) notes that closed-ended questions have the advantage of attaining greater uniformity of measurement and therefore greater reliability in guiding respondents to answer in a manner fitting the response category. Leedy and Ormrod (2010) further buttressed that applying a closed-ended question in research has the following advantages:

- The questions are short, precise and easy to answer.
- Coding and statistical analysis are easily done.

However, despite the numerous advantages of closed-ended questions, Maree and Pieterse (2007) stated the following as disadvantages of closed-ended questions:

- The answers are very simple with no background details
- Respondents may be cajoled to give answers they would never have given.
- Answering the questions are too easy, so answers given may mislead the researcher(s).

- Respondents' opinions might not be an option to choose from.
- The questionnaires are typically too lengthy.

3.7 Research design

According to Leedy and Ormrod (2010), *research design* is holistic processes referring to the general procedure of answering a research problem within a specified period of time (data collection, analysis and selection of relevant empirical material). Similarly, research design essentially implies the plan or strategy required for conducting a research work (Henn, Weinstein & Foard, 2006:3). Leedy and Ormrod (2010) and Henn *et al.* (2006) identified the following as characteristics of a reliable research design:

- The design must aim at obtaining measurable data; that is, data derived must be statistically based.
- The design must be replicable by other researchers within the same parameters.
- The research design must state the appropriate data analysis to be used and why.

The approach adopted for a research project is vital to the success or failure of any study

3.7.1 Research design for the study

Various studies have been undertaken to ascertain the effects of building material cost on sustainable housing delivery. Ihuah (2015) and Akanni *et al.* (2014) recognised the importance of analysing the role of sustainable building materials for construction works in an effort to promote sustainable housings. This process enables site engineers to determine how and when the project will be delivered. Notably, Akanni *et al.* (2014) noted that previous studies on cost of building materials only identified the causes, with little emphasis on the effect this has on delivery of housing. This present research project, then, by adopting a mixed method approach, explores the perceptions of construction stakeholders and site supervisors on the factors affecting the cost of building materials and its effect on housing delivery. The mixed approach was adopted for this study because it provides a more comprehensive perceptive of a phenomenon than either approach separately (Leedy & Ormrod, 2010). This research method was adopted specifically because it allows the opportunity to validate the data derived by using two or more research methods without bias.

The qualitative method was applied to evaluate the practice of sustainable construction. Therefore, site supervisor opinions were obtained through semi-structured interviews. The

quantitative method, moreover, was used to collect data from construction stakeholders (architects, quantity surveyors, engineers, construction managers, project managers and materials suppliers) and contractors to identify the factors causing increase in the cost of building materials, the effect on the delivery of affordable housings and the criteria to be considered in the selection of sustainable building materials for optimum usage. The research data was obtained with the aid of a structured questionnaire survey (quantitative method), which was validated by conducting semi-structured interviews (qualitative method) shortly after the questionnaire survey. The results and conclusions of this study are thus reliable and generalisable.

3.7.2 Exploratory study

An *exploratory study* is fundamental part of a research questionnaire design to gain more insight into the research problem and to provide solutions to them (Dahlberg & McCaig, 2010). Hence, Creswell (2011) recommends at pre-testing of a questionnaire, including groups within the larger group of potential research participants. Piloting the research tool helped in determining the possibility of answering the research questions using the data generated from the questionnaires, before proceeding to the main study. The questionnaire used for the exploratory study was piloted amongst construction stakeholders and post-graduate students from the department of Construction Management and Quantity Surveying, Cape Peninsula University of Technology, to certify the significance of the tool to the research. Neuman (2000:166) also emphasized that the use of pre-test or a pilot study questionnaire can improve the reliability of research work. The retrieved questionnaires for the exploratory study were analysed using Statistical Package for Social Science (SPSS) package.

3.7.3 Population and sample size

A *population* is defined as a collection of people, items or animals considered for a research study (Bryman 2004:87). Similarly, the term *population* is referred to the universe of units from which a sample is to be selected from this population (Bryman, 2004:87). Thus, it is important to note that the term *population* in research does not outrightly refer to a group of people being considered for study, but varies depending on the nature and field of the study. For the purpose of this research, the issue to be addressed is the effect of building materials cost on housing delivery. With that in mind, the populations considered are construction stakeholders (architects, quantity surveyors, engineers, the government, construction managers, project managers and materials suppliers) and contractors within the South African construction industry.

Flick (2015) described the *sample* of any population in research as a minimised representation of the larger population. The majority of survey participants are construction professionals with extensive construction knowledge, skill and formal educational, with the exception of site supervisors with minimum formal education but adequate construction background. Site managers, contract managers, project managers, site supervisors, architects, site engineers and quantity surveyors are the selected sample to represent the population for the purpose of this study. The study sample is therefore unarguably a suitable representation of construction stakeholders in South Africa.

3. 7.4 Sampling technique

O'Leary (2010) defined *sampling* as the process of breaking a large group of respondents into sections with the purpose of deriving results concerning the larger group. Furthermore, Maree (2007) indicated that sampling is the process of selecting randomly from a population to obtain a general finding of the whole population. Thus, it is necessary to note when conducting sampling that for a sample to represent a population, this is dependent on the sample frame, sample size and sampling design (Fowler & Consenza, 2009; Leedy & Ormrod, 2010). This research adopts purposive sampling techniques, considering the complex nature of the construction industry in relation to management, operations, geographical distribution and the often chaotic schedule of construction stakeholders. As a result, construction stakeholders and contractors in Cape Town and Paarl were selected as samples for the research population (Western Cape Province). The samples were selected by the use of *cluster sampling* and *purposive sampling technique*.

Biggam (2008) and Maree and Pieterse (2007) defined *cluster sampling* as a process of rearranging a target population into smaller groups (clusters), from which samples are randomly selected for data collection and result generalisation. Sampling techniques are important for researchers to decide on the number of respondents from which inference will be drawn and the techniques to adopt in their selection (sampling method) because of time and cost constraints (Ganiyu 2016:111). As mentioned earlier, based on the accessibility of the construction sites and availability of the construction stakeholders, as a result of their busy schedules, the questionnaires were administered to construction stakeholders and contractors in Cape Town and Paarl. Thus, the cluster sampling technique was adopted in the phase of questionnaire administration (quantitative data collection), for an easy and fast generalisation of findings. For the quantitative data collection, construction and consulting companies in Cape Town were grouped into clusters of ten (10) in which respondents were randomly selected using a simple random sampling method. A total of thirty (30) companies were randomly selected with at least six (6) representatives of each company. Construction

and consulting companies in Paarl were grouped into four (4) clusters; fifteen (15) companies were randomly selected with at least four (4) representatives from each company as respondents.

To validate the data obtained from the questionnaires, contractors and site supervisors were interviewed. These participants were selected for interviews using the convenience sampling method. Participants interviewed had adequate experience in construction, with adequate years of supervisory responsibilities in the construction sector. The experience of the site supervisors is arguably a helpful instrument to assess the validity of data obtained from construction stakeholders. Convenience sampling method, as the name implies, is a quick and inexpensive approach in research to validate information obtained in the course of a study (Maree, 2007).

3.7.5 Data collection techniques

Data collection entails the process of exploring a series of data sources to obtain information for a research study. Nonetheless, Struwig and Stead (2007:80) and Biggam (2015) stated two types of data collection in a research work: primary and secondary data. A triangulation data collection technique was adopted for this research; that is, data was not only collected through questionnaires, but also through interview and literature reviews. Literature reviews, questionnaires and interviews were used to obtain data for this study as subsets of secondary and primary data collection.

3.7.5.1 Secondary data collection

Secondary data are easily reached data obtained from research conducted by other researchers (Struwig & Stead, 2007:80). Further, secondary data can also be referred to as literature review in research. O'Leary (2010:71) emphasized that it is essential to consult past innovations for production of new knowledge. Melville and Goddard (2004) noted that the secondary data (literature review) is obtainable in two different forms: preliminary review and a comprehensive review of other research works. The preliminary review was adopted in Chapter One of this study to develop a framework for the study, while the comprehensive review of literature was conducted in Chapter Two of this study to evaluate and extend the views of other researcher on comparatively relevant topics. The data obtained from past research revealed diverse factors affecting the cost of construction and, specifically, the cost of building materials, as well as a significant number of factors explored from existing literature to assist in the design of the research questionnaire. Comparatively, most research was conducted concerning factors affecting cost of building materials, factors affecting the cost of construction, criteria to be considered in the selection of sustainable building

materials, while only an insignificant amount of research has addressed the effects of increase in the cost of building material on housing delivery. Thus, this research study poises to consider this lapse. The sources of information for the review of literature included textbooks, journals, articles, conference proceedings, dissertations and theses.

3.7.5.2 Primary data collection

Leedy and Ormrod (2010) highlighted the most valid information obtained in a research to be *primary data*. This method of data collection involves researchers making certain that the questions are designed for respondents in a clear and understandable manner to elicit thorough and fitting information (Kumar, 2011). The primary data for the study were collected through the administration of quantitative questionnaires to survey respondents as well as through interviews conducted face-to-face with site supervisors, while the questionnaires were administered to respondents by hand and via the internet (survey monkey).

3.7.5.2.1 Interview

This method of data collection is qualitative in nature and commonly open ended. However, Flick (2015) is of opinion that when conducting that qualitative interview there should be a dialogue between interviewer and interviewee. According to Leedy and Ormrod, (2010) interviews in a survey are designed in two forms: structured and semi-structured, depending on the purpose of the survey.

For the purpose of this study, a semi-structured qualitative interview was chosen, due to the advantage of the flexibility of semi-structured interviews. In agreement, Kumar (2011:160) stressed that interviews provide the researcher a level of spontaneity, flexibility and liberty to dialogue and interact with the survey respondents.

The respondents were informed prior to the meeting of the focus of the interview and the relevance of the research study, giving respondents sufficient time to prepare in advance. The interview was tape-recorded with permission from the respondents. A total of three (3) construction sites were selected for data validation (interview).

An interview was conducted with a site supervisor on each construction site selected for data validation, as site supervisors are in the most suitable position to disclose the factors that cause increases in the cost of building materials. Arguably, site supervisors have significant knowledge of the factors affecting the cost of building materials on construction projects.

3.7.5.2.2 Questionnaire design

The most essential aspect of any survey is the questionnaire design (Kumar, 2011). The research questionnaire, designed with close-ended questions, is designed in consonance with the study objectives as well as the information derived from reviewed literature.

The questionnaire was structured in sections, where each section addresses a particular objective. Table 3.4 illustrates the relationship between various sections and study objectives. The first section of the questionnaire inquires of the biographical information of the survey participants. The second section comprises four sub-sections, and addresses the first objective of the research with the aim of identifying the factors responsible for the increase in the cost of building materials. This section considers economic related factors, building production processes related factors, stakeholder related factors and external factors. The third section of the questionnaire identifies effects of increase in the cost of building on housing delivery. The final and fourth section is comprised of four sub-sections, which address the final objective of the study, with the aim of ascertaining the criteria to be considered in the selection of building materials for affordable housing. The sub-sections considered the influence of stakeholders on materials selection, guidelines for materials selection, criteria to be considered during materials selection and project factors affecting the types of materials to be selected.

Table 3.4: Questionnaire design

Section	Section title	Section objective
1	Biographical information	
2	Factors responsible for increase in cost of building materials	Objective 1
3	Effects of increase in the cost of building materials on housing delivery	Objective 2
4	Criteria for selection of sustainable building materials	Objective 3

3.7.6 Data analysis for the study

Data analysis includes tabulating, data testing, categorising and examining results to address the purpose of a study (Yin, 2003). The quantitative and qualitative data gathered were analysed using the Statistical Package for Social Sciences (SPSS) software. The quantitative data, obtained by questionnaires, were analysed with descriptive statistics. Conversely, the qualitative data were analysed technically by content analysis.

3.7.6.1 Descriptive statistics

Descriptive statistical analysis in research can be defined as the process of showing or briefing a set of quantitative data in clear formats (tables and charts, for example) (Quartaroli, 2009). Struwig and Stead (2007:158) posited that the purpose of using a statistical tool in data analysis is to show a direct picture of a large amount of data. Henn *et al.* (2006) and Leedy and Ormrod (2010) highlighted the three predominate terms used in descriptive statistical data analysis as central tendency measurement, dispersion measurements and frequency distributions. Thus, this study adopted the use of frequency distribution and central tendency measurement technique (mean and standard deviations) in analysing the quantitative data obtained in the survey.

3.7.6.2 Content analysis

Content analysis principally involves the coding and transcribing of human communication (written or oral) or other means of communication: videotapes and Internet blogs (Babbie, 2007; Leedy & Ormrod, 2010). Furthermore, Flick, (2015) added that this approach includes the summary of content, while irrelevant words are omitted. Notably, content analysis is an effective method for answering a large research questions. When compared with analysis of questionnaires, content analysis consumes more time in terms of data processing and transcribing (Thomas, 2003:60). The content analysis adopts the inductive approach in exploring the advantages and disadvantages of a text or statement in order to oppose or support a theory. In context, this study reported a summary of the relevant contents in the transcribed data obtained from the interviewees, while less important information was omitted in the reporting process.

3.8 Validity and reliability of the data

Validity and *reliability* of the research tool impact the authenticity of the research work. Struwig and Stead (2007) stressed that the validity of a research tool signifies the degree to which the tool measures the reason for which it was designed, while reliability makes sure there is consistency in findings whenever it is constantly used. Notably, the principles validity and reliability differ depending on the nature of the research conducted.

3.8.1 Validity

The *validity* of a research refers to the originality of the survey tool, hence, the research findings (Struwig & Stead, 2007:159). Leedy and Ormrod (2010) otherwise stated that the validity of a research is the extent to which the instrument used measures what it is

supposed to measure. Validity refers to the credibility of research findings (Struwig & Stead, 2007:159).

3.8.2 Reliability

Research reliability refers to the stability of a research result when used at different times or administered to different subjects from the same population (Leedy & Ormrod, 2010). The main reason for conducting reliability of a test is to reduce the inaccuracies and preferences in a survey (Yin, 2003). The Cronbach's Alpha test is one such statistical tool frequently used for assessing the reliability of data (Girden & Kabacoff, 2011). Thus, in the context of this study, the reliability of the questionnaire was assured by testing the questionnaire using the Cronbach's coefficient alpha. It was noted that the closer the coefficient is to 1, the more reliable the survey instrument is, with the optimal Cronbach's coefficient alpha value above 0.7.

3.9 Chapter summary

This chapter provided a comprehensive overview of the research methodology adopted in this study. A mixed research method (quantitative and qualitative) was adopted to achieve the aim and objectives of the research. The quantitative research questionnaire was structured and designed to elicit the perceptions of construction professionals and stakeholders on the effects of increase in the cost of building material on sustainable housing delivery in the Western Cape. Literature reviews, interviews and questionnaires were used in collecting both primary and secondary data for the study. The approaches used for questionnaire administration were both 'online' and 'hand-in' approaches. Thereafter, the reliability of the findings and results were tested using the Cronbach's alpha coefficient reliability test.

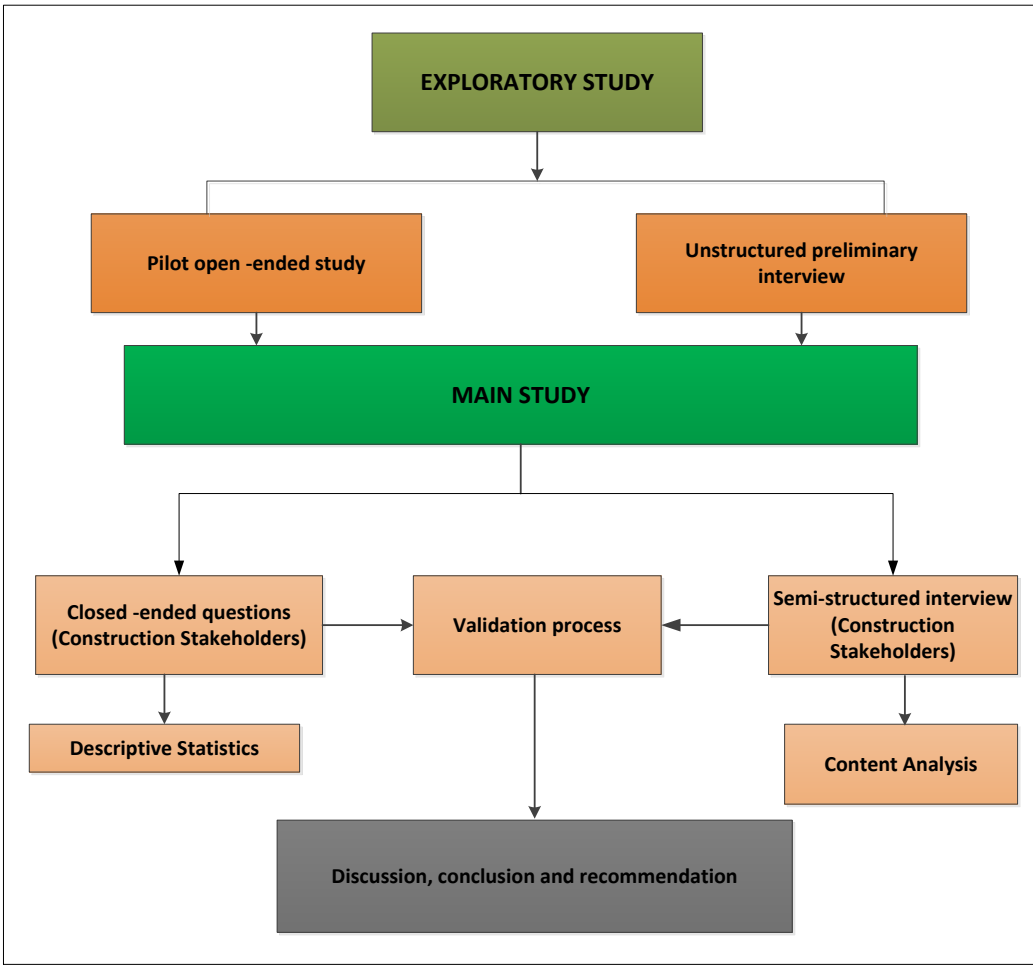


Figure 3.2: Research methodology

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF FINDINGS

4.1 Introduction

This chapter presents the results of a quantitative data analysis conducted using descriptive statistical techniques. Additionally, detailed accounts of participant responses during the qualitative interviews were reported and tabulated under appropriate sections. The results of statistical analysis were interpreted: inferences were drawn from the results and discussed thoroughly to bring the research conclusions into focus.

4.2 Exploratory study

The exploratory study was conducted in Cape Town, in the Western Province of South Africa. The study was conducted to identify the factors responsible for the increase in the cost of building materials, its effects on the delivery of affordable housing and criteria to be considered in the selection of building materials for sustainable housing delivery. The exploratory study was also conducted to ascertain questionnaire clarity for the main study in the industry. The study population was comprised of architects, site engineers, project managers, quantity surveyors, contractors and government workers. The population sampling technique adopted for the exploratory study was the 'simple random sampling method'. A total of twenty (20) questionnaires were administered. The respondents were requested to complete the questionnaire and make constructive comments where necessary. Successively, comments and further input from the respondents were considered and suitable modifications were made in the questionnaire design for the main study.

4.3 Questionnaire survey for the main study

Quantitative data collection for this study was conducted through the use of a questionnaire survey. A total of two hundred and twenty-five (225) questionnaires were administered to construction stakeholders (architects, site engineers, project managers, quantity surveyors, contractors, building materials suppliers, site managers and government workers) in the Western Cape Province of South Africa. One hundred and thirty-seven (137) questionnaires were administered in person to selected respondents, of which fifty-one (51) questionnaires were adequately completed and retrieved. Subsequently, eighty-eight (88) were

administered online via electronic mails: eighteen (18) questionnaires were completed and sent back electronically. Ultimately, then, sixty-nine (69) questionnaires were retrieved and used for analysis.

4.4. Biographical information of respondents

4.4.1 Participants' companies

The results in Figure 4.1 present the characteristics of the respondents from different work divisions, professions and companies. The information obtained was from both the private and public sector of the construction industry, with 13% of the respondents from project management firms; 29% of respondents from contracting firms; 10.1% from material suppliers; 21.7% from construction management firms; 11.6% from government establishments; 7.2% from quantity surveying firms; and 7.2% from architectural firms. From this result, it is evident that the majority of respondents undertook housing construction, an indication that the data provided by the respondents in their survey response could be relied upon for making decisions pertaining to sustainable housing construction.

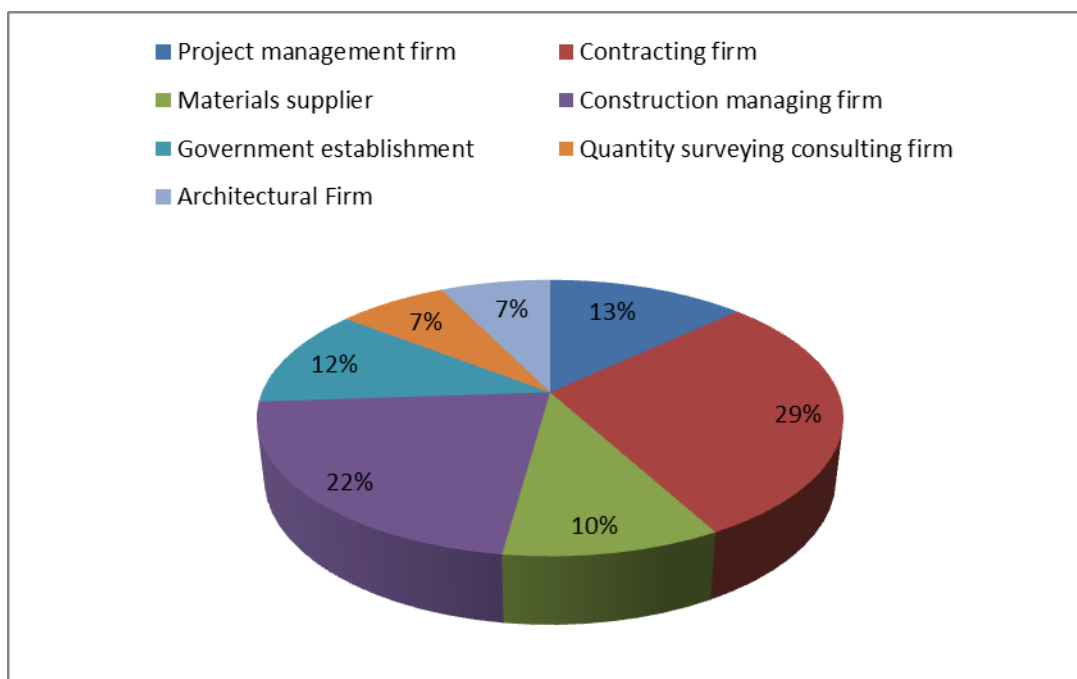


Figure 4.1: Participants' companies

4.4.2 Respondents' gender

Table 4.1 shows that the majority (84%) of survey participants are male, while female participants represent the only 16%. This gender distribution indicates that male participants

are significantly higher in number than their female counterparts. Nevertheless, this inference doesn't suggest that the female participation is not significantly reliable for this research study. In fact, these results proved that the respondents were qualified; inference suggests that equality of the gender is significantly consistent for this research study.

Table 4.1: Respondents' gender

Category	Frequency	Percentage
Male	58	84.1
Female	11	15.9
Total	69	100

4.4.3 Age group

Figure 4.2 presents the age groups of survey respondents. It was found that 11.6% of the respondents were below the age of twenty-six. The age group between twenty six to thirty years was made up of 23.2% of study participants. The highest percentage of respondents fell between the ages of thirty-one and thirty-five, representing 31.9% of the total respondents. The age group between thirty-six to forty made up 14.5% of study participants. The age group between fifty-one to fifty-five years made up 4.3% of study participants. Respondents falling between age forty-six and fifty represent of 11.6% of survey respondents. The table indicates that 97.1% of survey respondents were not older than sixty-five years of age, while a mere 2.9% respondents were above sixty-five years of age, suggesting that the majority of survey respondents were middle age. Analysis on respondents' age group showed that an overwhelming 97.1% were not older than sixty-five years of age, while only 2.9% respondents were above sixty-five years, proving that the respondents were qualified, competent and with certain and valid expertise on sustainable building projects and construction in general.

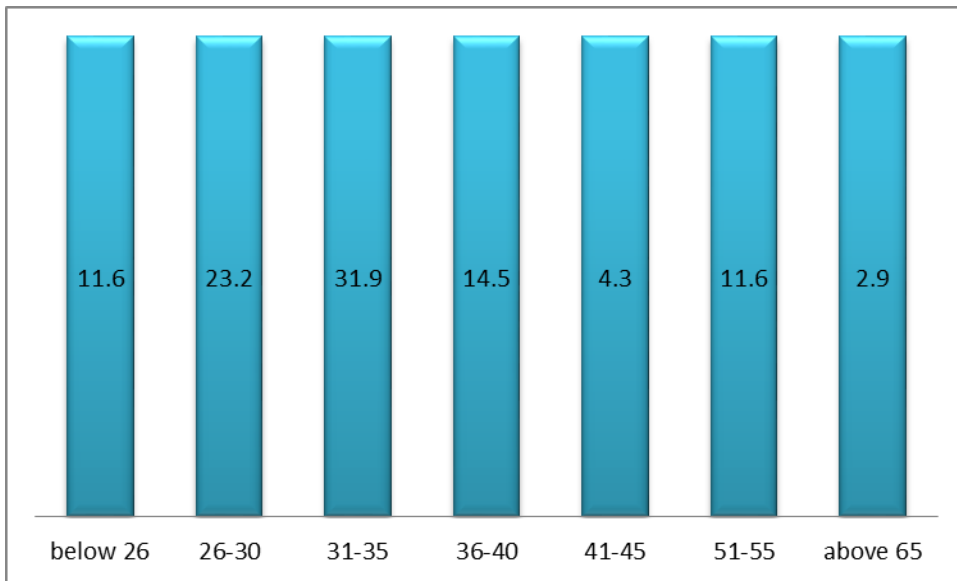


Figure 4.2: Respondents' age group

4.4.4 Highest formal qualifications

Figure 4.3 presents the formal qualifications obtained by the study participants. Respondents having diploma certificates as the highest formal educational qualification represented 58%. Respondents holding Post Graduate diplomas and Bachelor's degrees represented 38%. A minority of respondents (4%) hold Master's degrees in their various fields. Figure 4.3 reveals that highest formal educational qualification (at 58%) that survey respondents held was a Diploma Certificate. The results of analysis on respondent demographic and educational background information indicate that respondents were adequately knowledgeable practitioners in the construction industry, whose judgments on issues of construction project delivery can be relied on.

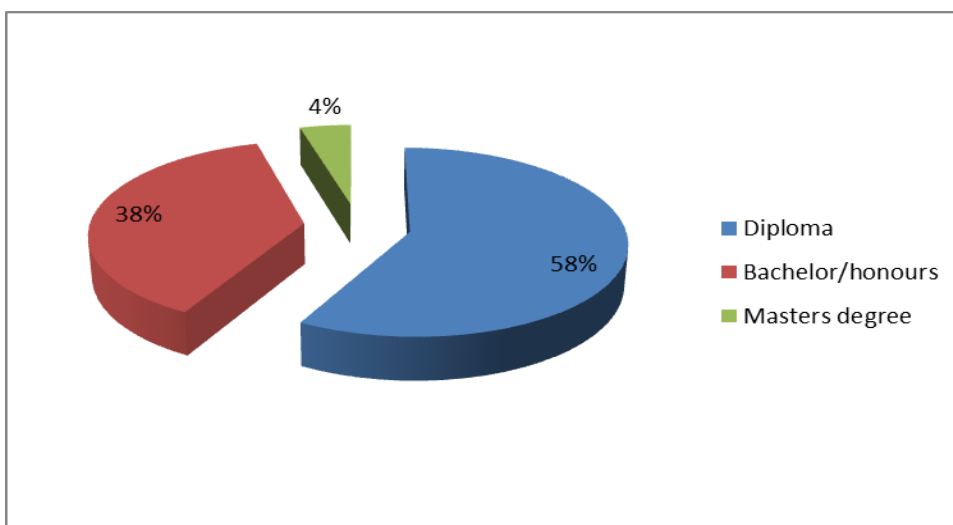


Figure 4.3: Highest formal qualifications

4.4.5 Position of respondents

Figure 4.4 presents the positions held by survey participants. The largest groups of the respondents (20.3%) were project managers, followed by quantity surveyors which represented 17.4%; and site managers at 11.6%; construction managers at 13%; 11.6% were sales consultants; contractors at 7.2%, site managers at 5.8%; and architects at 13%. The outlook of results in Figure 4.4 shows that the geographical spread of the respondents within the building construction industry can be declared nearly perfect even and thus serve as reliable data. Similarly, the opinions of various stakeholders in the construction will enhance the result reliability.

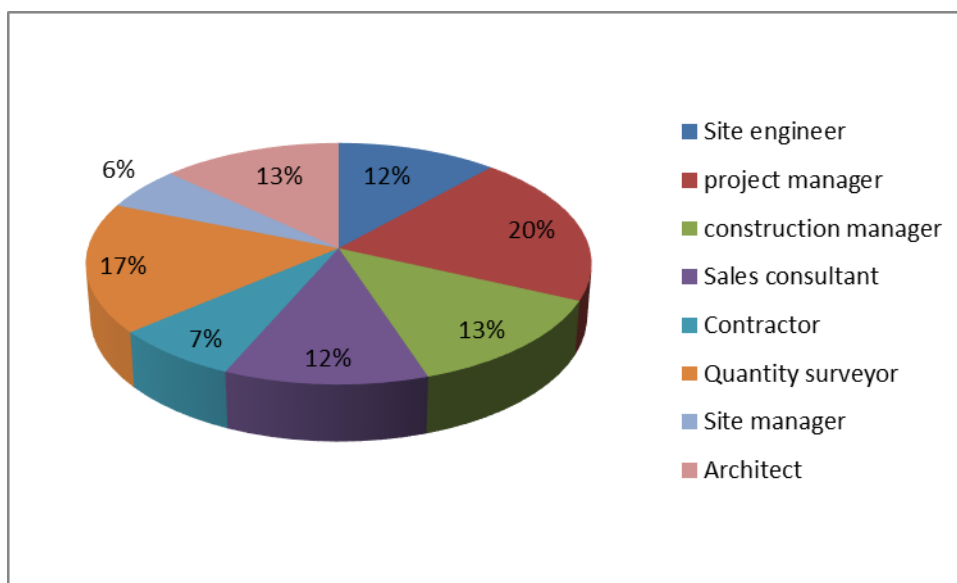


Figure 4.4: Position of the respondents

4.4.6 Numbers of years in the present position

Figure 4.5 presents that 7% of the respondents had been in their current position below one year; 23% had been working in the position for one to five years; 42% had been in the position for six to ten years; 18% had been in their position for eleven to fifteen years; 7% had been in the current position for sixteen to twenty years; and 3% had been in their current position above twenty years. The results of analysis on respondent demographics revealed that of respondents sampled, 93% has been in their current position for more than five years, indicated that the respondents were thoroughly qualified, having gained much experience from their present and previous firms in construction industry.

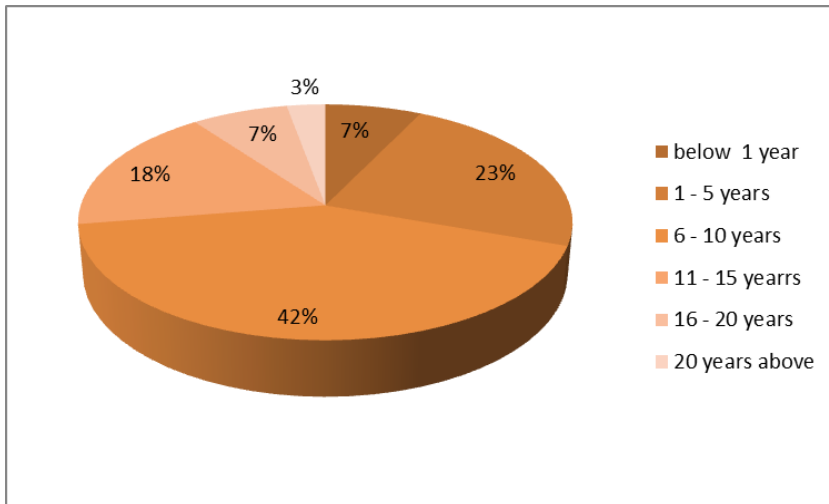


Figure 4.5: Years in present position

4.4.7 Experience of respondents

Table 4.2, presents the work experience of respondents in the construction sector, reveals respondents with one to five years' work experience in the construction industry represented 7.2% of the total respondents. Respondents having six to ten years construction work experience represented 10.1% of the total. A substantial 36.2% of study participants had been involved in construction work for eleven to fifteen years, while 21.7% had sixteen to twenty years' experience, and 24.6% had construction experience of greater than twenty years. Also from Table 4.2, the working experience of the minority of respondents (17%) in the construction industry spanned between one to ten years, while 58% of respondents had been working in the construction sector for more than ten years. The years of experience of respondents are significantly worthy to achieve the purpose of the study, as a significant 83% of study respondents have more than ten years work experience in the construction industry. Nonetheless, this is not to suggest that the input and work experiences of the respondents working only between 1-5 years is not significantly reliable for this research.

Table 4.2: Experience of respondents in the construction industry

Category	Frequency	Percentage
1 - 5 years	5	7.2
6 - 10 years	7	10.1
11- 15 years	25	36.2
16-20 years	15	21.7
20 years above	17	24.6
Total	69	100

4.5 Testing the reliability of the research Instrument

The reliability of the questions used in the study was tested with the Cronbach's alpha test using a Statistical Package for Social Sciences (SPSS) version 24, as this ensures reliability of research questions. Cronbach's alpha reliability test is an estimate of the internal consistency associated with the scores that can be derived from a scale or composite score (Tavakol & Dennick, 2011:53). Data in Table 4.3 shows that the Cronbach's alpha coefficient values are greater than 0.70 (>0.70), and Tavakol and Dennick (2011:53) endorsed that the score values between 0.70-0.95 are standardized values for the reliability of a test to be secured.

Table 4.3 Reliability of research instrument

Question numbers	Headings	Number of the items	Cronbach's alpha coefficient value
Section B1	Economic related factors responsible for increase in the cost of building materials	10	0.7
Section B2	Building production process related factors responsible for increase in the cost of building materials	22	0.7
Section B3	Stakeholder related factors responsible for increase in the cost of building materials	7	0.7
Section B4	External factors related factors responsible for increase in the cost of building materials	10	0.8
Section C	Effects of increase in the cost of building materials on housing delivery	23	0.9
Section D1	Influence of stakeholder in selection of building materials	9	0.7
Section D2	Guidelines to materials selection in construction towards enhancing sustainable building delivery	10	0.8
Section D3	Criteria often considered during materials selection for optimum materials usage in relation to sustainability categories	29	0.8
Section D4	Project factors affecting materials selection	10	0.8
	All questions used	131	0.9

4.6 Presentation of findings

The study is designed to identify effects of significant factors affecting building materials cost on housing delivery towards sustainability in South Africa. From the findings, the significant factors affecting the cost of building materials, its effects in the delivery of sustainable housing and criteria often considered in the selection of building materials are presented.

4.6.1 Economic related factors responsible for increase in cost of building materials

Table 4.4 presents the perceptions of survey respondents in the order of severity of economic related factors affecting the cost of building materials. Respondents were requested to indicate the extent to which each of the identified factors affected the cost of building materials, following a four (4) point Likert scale: 4=Strongly agree, 3=Agree, 2=Disagree and 1=Strongly disagree. In Table 4.4, inflation, with a mean value of 3.55, was identified as the most significant economic related factor affecting the cost of building materials. A high 94.2% of respondents strongly agreed that this factor affects the cost of building materials, whereas a minority (5.8%) of respondents disagreed, indicating that does not affect the cost of building materials. However, it can be inferred that this factor is widely regarded as a major contributor to the increase in cost of building materials. Overwhelming number of respondents 97.1% agreed that exchange rate of Rand (mv=3.53) was a notable factor affecting cost of building materials. Thus, this factor maintained a slightly closer mean value as inflation, while 2.8% of the respondents disagreed that this factor was significant. Another large percentage (92.8%) of respondents agreed that interest rate (mv=3.38) is an important factor affecting cost of building materials, and 88.4% of respondents perceived that cost of building materials (mv=3.33) as a notable economic related factor responsible for increase in the cost of building materials (Table 4.4).

Table 4.4 Economic related factors

Economic related factors	No.	Strongly agree (%)	Agree (%)	Disagree (%)	Strongly disagree (%)	Mean value (mv)	Std.D	Rank (r)
Inflation	69	60.9	33.3	5.9	0.0	3.55	0.61	1
Exchange rate of Rand	69	56.5	40.6	1.4	1.4	3.52	0.60	2
Interest rate	69	44.9	47.9	7.2	0.0	3.38	0.62	3
Cost of building materials	69	44.9	43.5	11.6	0.0	3.33	0.68	4
Market condition	69	44.9	36.2	18.8	0.0	3.26	0.76	5
Fluctuation in the cost of raw materials	69	36.2	50.7	13.0	0.0	3.23	0.67	6
Local taxes	69	34.8	46.4	14.5	4.3	3.12	0.81	7
Supply and demand of building materials	69	31.9	44.9	21.7	1.4	3.07	0.77	8
Inadequate production of building materials	69	27.5	39.1	31.9	1.4	2.93	0.81	9
Scarcity of building materials	69	21.7	52.2	21.7	4.3	2.91	0.78	10

4.6.2 Building production related factors responsible for the increase in cost of building materials

Table 4.5 presents the perception of the respondents on building production related factors responsible for increase in the cost of building materials towards enhancing sustainable housing delivery. The respondents were required to use a four (4) point Likert scale: 1=Strongly disagree, 2=Disagree, 3=Agree, 4=Strongly disagree. The findings from the table shows that wastages of building materials by workers (mv=3.31) and poor site planning preventing easy movement of materials (mv=3.15) are significant site related factors responsible for increase in the cost of building materials. While cost of transportation and distribution of labour (mv=3.28), cost of power supply (mv=3.24) and cost of labour (mv=3.17) were identified as top human related factors. The table also shows that design changes (mv=3.36), additional work due to change in design (mv=3.29) and wrong method of estimation by quantity surveyor (mv=3.24) as design related factors responsible for increase in the cost of building materials towards sustainable housing delivery.

Table 4.5: Building production related factors responsible for increase in cost of building materials

Building production related factors	No.	Strongly agree (%)	Agree (%)	Disagree (%)	Strongly disagree	Mean value (mv)	Std.D	Rank (r)
Site related factors								
Wastages of building materials by labourers	69	40.6	50.7	8.7	0.0	3.31	0.63	1
Poor site planning prevent easy movement of materials	69	52.2	20.3	18.8	8.7	3.15	1.02	2
Inadequate infrastructural facilities	69	18.8	65.2	15.9	0.0	3.03	0.59	3
Unsuitable location for building materials storage	69	27.5	47.8	21.8	2.9	3.00	0.79	4
Cost of fuel	69	29.0	46.4	18.8	5.8	2.94	0.85	5
Pilferage of materials on site	69	18.8	56.5	24.6	0.0	2.94	0.66	6
Shortage of building materials on site	69	20.3	49.3	24.6	5.8	2.84	0.82	7
Human related factors								
Cost of transportation and distribution of labour	69	40.6	46.4	13.0	0.0	3.28	0.68	1
Cost of power supply	69	43.5	39.1	15.9	1.4	3.24	0.77	2
Cost of labour	69	44.9	33.3	15.9	5.8	3.17	0.91	3
Cost of plant	69	31.9	52.2	13.2	2.9	3.13	0.74	4
Communication problem between labourer and supervisors	69	34.4	39.1	24.6	1.4	3.07	0.81	5
Cost of fuel	69	31.9	39.1	21.7	7.2	2.96	0.91	6
Lack of discipline among labourers	69	24.6	40.6	26.1	8.7	2.81	0.91	7
Delay in the payment of construction labourers	69	15.9	42.0	29.0	13.0	2.81	0.91	8
Design related factors								
Design changes	69	37.7	49.9	11.6	1.4	3.36	0.75	1
Additional work due to change in design	69	37.7	55.1	5.8	1.4	3.29	0.64	2
Wrong method of estimation by quantity surveyor	69	42.0	43.5	11.6	2.6	3.24	0.77	3
Construction design complexity	69	43.3	42.0	10.1	4.3	3.24	0.71	4
Additional work due to errors	69	37.7	49.3	11.6	1.4	3.23	0.79	5
Design team experience	69	39.1	39.1	20.3	1.4	3.16	0.79	6
Inadequate coordination among design team	69	26.1	59.4	14.5	0.0	3.12	0.63	7

4.6.3 Stakeholder related factors responsible for increase in cost of building materials

Table 4.6 presents findings on stakeholder related factors responsible for increase in the cost of building materials. The respondents were required to use a four (4) point Likert scale:

1=Strongly disagree, 2=Disagree, 3=Agree, 4=Strongly disagree. The majority of the respondents (89.9%) agreed on client contribution to design change (mv=3.28) as a top stakeholder related factor responsible for increase in the cost of building materials. Most of the respondents (92.8%) indicated that incorrect construction method (mv=3.19) was also a notable factor responsible for increase in the cost of building. Improper planning (mv=3.17), client demand on high quality project delivery (mv=3.16), and supplier default (mv=3.14) were also identified as contributory factors to an increase in cost building materials.

Table 4.6: Stakeholder related factors responsible for increase in the cost of building materials

Stakeholder related factors	No.	Strongly agree (%)	Agree (%)	Disagree (%)	Strongly disagree (%)	Mean value (mv)	Std.D	Rank (r)
Client contribution to design change	69	37.7	52.2	10.1	0.0	3.28	0.63	1
Incorrect construction method	69	29.0	63.8	4.3	2.9	3.19	0.64	2
Improper planning	69	39.1	42.0	15.9	2.9	3.17	0.80	3
Client demand on high quality project delivery	69	39.1	42.0	15.9	2.9	3.16	0.72	4
Supplier default	69	34.8	49.3	11.6	4.3	3.14	0.79	5
Delay in the supply of materials on site	69	21.7	52.2	11.6	8.7	3.09	0.87	6
Fraudulent activities	69	21.7	52.2	23.2	2.9	2.92	0.75	7
Contractor issue (change initiated by contractor to improve quality)	69	23.3	43.5	26.1	7.2	2.82	0.87	8

4.6.4 External factors responsible for increase in the cost of building materials

Table 4.7 presents external factors responsible for increase in the cost of building materials. The respondents were required to use a four (4) point Likert scale: 1=Strongly disagree, 2=Disagree, 3=Agree, 4=Strongly disagree. Increase in cost of hiring construction machineries (mv=3.02) emerged as the highest rated external factor responsible for increase in the cost of building materials. A high percentage (82.6%) of respondents agreed that this factor significantly affected cost of building material, while 17.4% of respondents disagreed that increase in cost of hiring construction machineries affected the cost of building materials. Government legislation (mv=3.01) and change in government policies and regulations (mv=3.00) were seen as notable external factors, as indicated by respondents in Table 4.7.

Table 4.7: External factors responsible for increase in the cost of building materials

External factors	No.	Strongly agree (%)	Agree (%)	Disagree (%)	Strongly disagree (%)	Mean value (mv)	Std.D	Rank (r)
Change in government policies and regulation	69	21.7	60.9	15.9	1.4	3.02	0.66	1
Government legislations	69	18.8	66.7	11.6	2.9	3.01	0.65	2
Lack of substitute for product	69	23.2	55.1	17.4	4.3	3.00	0.76	3
Level of advanced technology	69	23.2	53.6	18.8	4.3	2.95	0.77	4
Increase in cost of hiring construction machineries	69	21.7	52.2	24.6	1.4	2.94	0.73	5
Poor nature of construction site	69	21.7	56.5	14.5	7.2	2.92	0.81	6
Weather condition	69	26.1	44.9	23.2	5.8	2.91	0.85	7
Effect of rainfall on building materials	69	20.3	50.7	23.2	5.8	2.85	0.81	8
Political interference	69	17.4	53.6	20.3	8.7	2.80	0.83	9
Force majeure (natural occurrences)	69	17.4	47.8	30.4	4.3	2.78	0.78	10

4.6.5 Effects of increase in the cost of building materials on housing delivery

Table 4.8 presents effects of increase in the cost of building materials on housing delivery. Respondents were required to indicate the extent to which each of the identified factors has an effect on housing delivery using a four (4) point Likert scale with values as follows: 4=to a very large extent, 3=to a large extent, 2=to a little extent, 1=not at all. A significant 89.9% of respondents indicated fluctuation in cost of construction (mv=3.26) was ranked as top most significant effect of increase in the cost of building materials on delivery of affordable housing. High maintenance costs due to poor workmanship (mv=3.23) emerged as the second critical factor affecting housing delivery, while 84.1% of the respondents indicated that increase in the cost of repair due to inferior materials used (mv=3.19) has a significant effect on delivery affordable housing. Poor workmanship (mv=3.14) and client expectation on quality project delivery (mv=3.11) were identified to have a large extent on the delivery of affordable housing. Building collapses due to the use of poorer quality materials (mv=3.10), conflict between client and contractor due to upward review of contract sum (mv=3.10), delay on the progress of project works (mv=3.10) were indicated as a notable effects on housing delivery. All maintained the same mean value, although less significant than one another, considering the standard deviation of the three factors.

Table 4.8: Effects of increase in the cost of building materials on housing delivery

Effects	No.	To a very large extent (%)	To a large extent (%)	To a little extent (%)	Not at all (%)	Mean value (mv)	Std.D	Rank (r)
Fluctuation in cost of construction	69	37.7	52.2	8.7	1.4	3.26	0.68	1
High maintenance cost due to poor workmanship	69	36.2	50.7	13.0	0.0	3.23	0.67	2
Increase in the cost of repair due to inferior materials used	69	31.9	56.5	10.1	1.4	3.19	0.67	3
Poor workmanship	69	31.9	52.2	14.5	1.4	3.14	0.71	4
Affect client expectation's on quality project delivery	69	33.3	46.4	18.8	1.4	3.11	0.75	5
Building collapses due to the use of less quality materials	69	34.8	43.5	18.8	2.9	3.10	0.80	6
Conflict between client and contractors due to upward review of contract sum	69	34.8	44.9	15.9	4.3	3.10	0.82	7
Delay on the progress of project works	69	26.1	60.9	10.1	2.9	3.10	0.69	8
Poor quality of construction product	69	21.7	65.2	13.0	0.0	3.09	0.58	9
Increase in final cost of building products, that is final cost of production higher than budgeted	69	31.9	47.8	15.9	4.3	3.07	0.81	10
High rate of contractors' fraudulent practices	69	27.5	53.6	17.4	1.4	3.07	0.71	11
Low income earners are priced out for home ownership due to high cost of building	69	31.9	49.3	11.6	7.2	3.06	0.86	12
Affect the aesthetics value of building product	69	20.3	65.2	13.0	1.4	3.04	0.63	13
Shortage in the delivery of housing to the populace	69	29.0	50.7	15.9	4.3	3.04	0.79	14
Affect gross domestic product (GDP) contribution to the economy	69	21.7	62.3	13.0	2.9	3.03	0.68	15
Investment return on construction project are delayed	69	27.5	52.2	15.9	4.3	3.02	0.79	16
Threatening health and safety of workers on site	69	27.5	49.3	20.3	2.9	3.01	0.77	17
Completion at the expense of other projects	69	23.2	50.7	24.6	1.4	2.96	0.74	18
Low volume of construction product	69	17.9	60.9	20.3	1.4	2.94	0.66	19
Transportation cost – e.g. returning substandard materials to the supplier	69	26.1	50.7	14.5	8.7	2.94	0.87	20
Increase in project abandonment	69	21.7	47.8	27.5	2.9	2.88	0.78	21
Hindered adequate implementation of innovation in construction	69	17.4	60.9	20.3	1.4	2.87	0.62	22
Unemployment of construction workers	69	23.2	33.3	37.7	5.8	2.74	0.89	23

4.6.6 Influence of stakeholders in materials selection

Table 4.9 provides a summary of the results of respondents. Respondents were asked to rank the level of involvement of relevant stakeholders on a four (4) point Likert scale: 4=Higher, 3=High, 2=Low and 1=Very low as involved in the influencing of materials selection. Client (mv=3.43) has the highest degree of involvement while none of respondents indicated that client has a low degree involvement influencing materials selection. Architect and designer (mv=3.40) and technical consultant (mv=3.10) were identified by the respondents as having a high influence in the materials selection.

Table 4.9: Influence of stakeholders in materials selection

Stakeholders	No.	Very High (%)	High (%)	Low (%)	Very Low (%)	Mean value (mv)	Std.D	Rank (r)
Client	69	55.1	33.3	11.6	0.0	3.43	0.69	1
Architect and designer	69	59.4	29.0	4.3	7.2	3.40	0.88	2
Technical consultant	69	33.3	57.7	8.7	7.2	3.10	0.84	3
Project manager	69	30.4	30.4	23.2	15.9	2.75	1.06	4
Quantity surveyor	69	29.0	30.4	27.5	13.0	2.75	1.09	5
Suppliers of materials	69	29.0	29.0	23.2	18.8	2.68	1.09	6
Materials manufacturer	69	26.1	26.1	27.5	20.5	2.58	1.09	7
Contractors	69	23.2	30.4	27.5	18.8	2.57	1.05	8
Site manager	69	11.6	34.4	34.4	18.8	2.39	0.93	9

4.6.7 Guidelines to materials selection in construction towards enhancing sustainable housing delivery

Table 4.9 presents the important of definite guidelines to materials selection in construction towards enhancing sustainable housing delivery. These guidelines were evaluated by the respondents based on a four (4) point Likert scale: 4=Extremely important, 3=Important, 2=Less important and 1=Not important. A significant percentage (86.3%) of the respondents agreed building design (mv=3.36) is important in enhancing sustainable housing delivery in construction. Most of the respondents (86.6%) also agreed that in selecting sustainable building materials, it is imperative to consider the environmental impact of the materials

(mv=3.35). Material life cost (mv=3.23) was identified by the respondents as another key guideline to material selection for enhancing sustainable housing delivery. Moreover, material functional demands, material market trend demands and technological impact of materials were considered as important guidelines to material selection and were consequently ranked based on the mean value of 3.20, 3.12 and 3.11, respectively.

Table 4.10: Guidelines to materials selection in construction towards enhancing sustainable building delivery

Guidelines	No.	Very important (%)	Important (%)	Less Important (%)	Not important (%)	Mean value (mv)	Std.D	Rank (r)
Building design	69	42.8	43.5	5.8	2.9	3.36	0.73	1
Environmental impact of materials	69	47.8	39.1	11.6	1.4	3.33	0.74	2
Material life cycle cost	69	33.3	56.5	10.1	0.0	3.23	0.62	3
Material functional demands	69	33.3	53.6	13.0	0.0	3.20	0.65	4
Material market trend demands	69	24.6	62.3	13.00	0.0	3.12	0.61	5
Technological impact of materials	69	29.0	53.6	17.6	0.0	3.11	0.68	6
Material structural demands	69	24.6	60.9	14.5	0.0	3.10	0.63	7
Material efficiency (use of renewable and recyclable materials)	69	29.0	47.8	17.4	5.8	3.00	0.84	8
Socio economic impact of materials	69	34.8	29.0	30.4	5.8	2.93	0.94	9
Material overview	69	18.8	47.8	33.3	0.0	2.86	0.71	10

4.6.8 Sustainable criteria for building materials selection

Table 4.11 shows the ranking results for each criteria category (e.g. socio economic, environmental and technological). Respondents were asked to rate the level of importance of the derived criteria based on a four (4) point Likert scale: 4=Extremely important, 3=Important, 2=Less important, and 1=Not important. Maintenance cost was ranked as the first priority in the socio economic category, with a mean value of 3.36. Energy consumption (mv=3.34) was also ranked as having major significance under the environmental category, while maintainability (mv=3.43) had the highest ranking in the technical category and interestingly was the highest among all the selection criteria. According to Table 4.11, a total of 12 critical criteria, consisting of four environmental criteria, four technical criteria, and four

socio economic criteria, were recorded to have high levels of importance for evaluating building materials. These twelve criteria are 'maintainability' (T1), 'life expectancy' (T2), 'maintenance cost' (S1), 'energy consumption' (E1), 'health and safety' (S2), 'fire resistance' (T3), 'initial cost' (S3), 'disposal cost' (S4), 'minimise pollution' (E2), 'resistance to decay' (T4), 'air quality' (E3), and 'low or non-toxicity' (E4) with the following mean values of 3.43, 3.41, 3.36, 3.34, 3.34, 3.30, 3.29, 3.26, 3.23, 3.23, 3.22, and 3.21, respectively.

Table 4.11: Sustainable criteria for building materials selection

Criteria	No.	Extremely important (%)	Important (%)	Not important (%)	Less important (%)	Mean value (mv)	Std.D	Rank (r)
Socio- Economic criteria								
Maintenance cost	69	42.0	52.2	5.8	0.0	3.36	059	1
Health and safety	69	49.3	39.1	8.7	2.9	3.34	0.76	2
Initial cost	69	44.9	39.1	15.9	0.0	3.29	0.73	3
Disposal cost	69	34.8	56.5	8.7	0.0	3.26	0.61	4
Aesthetics	69	29.0	52.2	18.8	0.0	3.10	0.68	5
Labour availability	69	36.2	37.7	18.8	7.2	3.02	0.92	6
Recycle cost	69	29.0	42.0	21.7	7.2	2.93	0.89	7
Use of local materials	69	20.3	49.3	23.2	7.2	2.83	0.84	8
Transportation cost	69	20.3	36.2	40.6	2.9	2.74	0.82	9
Environment criteria								
Energy consumption	69	52.2	30.4	17.4	0.0	3.34	0.76	1
Environmental pollution	69	39.1	44.9	15.9	0.0	3.23	0.71	2
Air quality	69	42.0	39.1	17.4	1.4	3.22	0.76	3
Low or non-toxicity	69	43.5	36.1	18.8	1.4	3.21	0.80	4
Sound disposal options	69	34.8	44.9	18.8	1.4	3.13	0.77	5
Embodied energy in the material	69	34.8	43.5	21.7	0.0	3.13	0.75	6
Environmental statutory compliance	69	31.9	46.4	21.7	0.0	3.10	0.73	7
Green gas emission	69	29.0	50.7	20.3	0.0	3.08	0.70	8
Amount of likely wastage in the use of materials	69	27.5	53.6	17.4	1.4	3.07	0.71	9
Ozone depletion potential	69	27.5	47.8	20.3	4.3	2.99	0.81	10
Potential for recycling as well as re-use	69	24.6	43.5	27.5	4.3	2.88	0.83	11
Technical criteria								
Maintainability	69	49.3	44.9	5.5	0.0	3.43	0.61	1
Life expectancy of materials (strength, durability)	69	58.0	27.5	11.6	2.9	3.41	0.81	2
Fire resistance	69	42.0	46.4	11.6	0.0	3.30	0.67	3
Resistance to decay	69	37.7	49.3	11.6	1.4	3.23	0.71	4
Energy saving and thermal insulation	69	46.4	29.0	23.2	1.4	3.20	0.71	5
Moisture resistance	69	39.1	40.6	17.4	2.9	3.16	0.82	6
Ease of construction	69	33.3	49.3	17.4	0.0	3.15	0.70	7
Material availability	69	29.0	59.4	8.7	2.9	3.14	0.69	8
Sound insulation	69	21.7	62.3	15.9	0.0	3.06	0.62	9

4.6.9 Project factors

Table 4.11 presents the perception of the respondents on the project factors determining the nature and type of materials to be selected. Respondents were requested to indicate the extent to which each of the identified project factors affect the nature and type of materials to be selected, using a four (4) point Likert scale with values as follows: 4=To a very large extent, 3=To a large extent, 2=To a little extent, 1=Not at all. The majority (94.2%) of respondents indicated that client preference (mv=3.55) is an important factor in determining the nature and type of materials to be selected. However, a minority of respondents (4.3%) indicated that this has little impact in the selection of building materials, and 1.4% indicated that it actually has no impact at all. Complexity of project and budgeted project cost, with mean values of 3.40 and 3.30 respectively, were rated by respondents as having a large impact in the selection building materials.

Table 4.12: Project factors

Factors	No.	To a very large extent (%)	To a large extent (%)	To a little extent (%)	Not at all (%)	Mean value (mv)	Std.D	Rank (r)
Client preference	69	62.3	31.9	4.3	1.4	3.55	0.65	1
Complexity of project	69	49.3	42.0	8.7	0.0	3.40	0.64	2
Budgeted project cost	69	43.5	43.5	13.0	0.0	3.30	0.69	3
Scope of project	69	37.7	52.2	7.2	2.9	3.25	0.72	4
Stakeholder expectation	69	37.7	49.3	13.0	0.0	3.24	0.67	5
Project schedule	69	37.7	50.7	8.7	2.9	3.23	0.73	6
Size of project	69	40.6	44.9	10.1	4.3	3.21	0.80	7
Site condition	69	33.3	50.7	15.9	0.0	3.17	0.69	8
Nature of the project	69	24.6	65.2	10.1	0.0	3.14	0.58	9
Type of project	69	21.7	62.3	11.6	4.3	3.01	0.72	10

4.7 Discussion of findings

4.7.1 Factors responsible for increase in the cost of building materials

One of the objectives of this study is to examine factors responsible for increase in cost of building material that hinders sustainable housing delivery, as earlier stated. In this section, the study considers factors related to the economy, building production processes, stakeholders and external factors.

4.7.1.1 Economic related factors

The findings reveal inflation, with a mean value of 3.55, as the most significant economic factor responsible for increase in the cost of building materials (see Table 4.4). The construction industry is exposed to inflation in cost of building materials since it involves a truly excessive use of building materials for erecting building (Oghenekevwe *et al.*, 2014). One of the principal goals in any economy is price stability (Oyediran, 2003). However, with the rate at which inflation is presently ravaging global economies, particularly in developing countries, this seems to be an uphill task (Monye-Emina, 2007). Kaming *et al.* (1997) indicated that inflationary increases in building material cost are the main cause of construction cost overrun. The finding also indicated that exchange rate of Rand and interest rates are additional factors responsible for increase in the cost of building materials. In the assessment, Owoeye (2003) posited one factor influencing exchange rate as the inflation rate. The findings of Agene (1991) further supported that changes in imports and exports of any country will immediately affect the rate of exchange for its currency. Interest rates and inflation affect the value of investment, thereby hindering economic growth (Donald, 2005). To concur, Windapo and Cattell (2013) observed that high interest rates pose as a huge challenge to the construction industry because they are the prime default by construction industry clients.

4.7.1.2 Building production process related factors responsible for increase in cost of building materials

This study explored the perception of the respondents concerning building production process related factors responsible for increase in the cost of building materials. The study also evaluated the site related factors, human related factors and the design related factors.

4.7.1.2.1 Site related factors

Material waste has been acknowledged as the most important problem in the construction industry with significant consequences both for the productivity of the industry and for the environmental impact of construction projects (Gulghane *et al.*, 2015:62). Findings from this study revealed that waste of building materials by labourers is indeed a significant factor responsible for increase in the cost of building materials (Table 4.5). The factor has a mean value of 3.31. Wastages of building materials by labourers on site can be attributed to lack of

supervision or lack of skilled labour. This is in affirmation to the study undertaken by Nagapan *et al.* (2012) showing that a significant percentage of labour has little or no experience in construction. Therefore, inexperienced foremen add to more substandard works and reworks as well as inexperienced field supervisor (Nagapan *et al.*, 2012). The findings also indicated that poor site planning preventing easy movement of materials is another major factor responsible for increase in the cost of building materials. Inadequate planning and poor control may lead to rework of a building. Equally, the lack of planning of construction activities contributes to material waste (Polat & Ballard, 2004). Other factors indicated by the findings include inadequate infrastructural facilities and unsuitable location for building materials storage.

4.7.1.2.2 Human related factors

The findings revealed cost of transportation and distribution of labour (mv=3.28), cost of power supply (mv=3.24), cost of labour (mv=3.17) and cost of plant (mv=3.13) were the primary human related factors responsible for increase in the cost of building materials. Insufficiency of skills on the part of construction labourers frequently results in construction rework, reduced speed of work and overall disturbance of the general construction performance (Ameh & Osegbo 2011; Soham & Rajiv 2013; Durdyev *et al.*, 2012). High transportation costs have a knock on effect on the labours, as high transport cost has been acknowledged as a factor responsible for increase building materials costs in some developing countries in Africa (Windapo & Cattell, 2012:191). The findings also revealed that a communication problem between labourers and supervisors was another factor responsible for increase in the cost of building materials. Takim (2009) proposed that communication proficiency should be encouraged to attain greater efficiency and uniformity in decision making.

4.7.1.2.3 Design related factors

This study explored the perception of construction stakeholders concerning design related factors responsible for increase in the cost of building materials. Several studies acknowledge the adverse impacts of client/design professionals on construction project performance. The findings show that design changes (with a mean value of 3.36) and additional work due to change in design (m=3.29) are design related factors responsible for increase in the cost of building materials (Table 4.5). Design changes may well contribute to additional works (Han *et al.*, 2013). Change in construction design is inevitable and can arise for a number of reasons. However, these design changes do require extra time, extra cost

and extra materials. This concurs with Al-Dubaisi (2000) who determined that a change in design will have an impact on the material cost, schedule and cost of labour. Also, the findings identified the wrong method of estimation by quantity surveyor as a factor responsible for increase in the cost of building materials. This leads to rework which will naturally increase material cost. Most rework circumstances arise from changes, damages, defects, mistakes and errors (Rahman *et al.*, 2015). A study undertaken by Love *et al.* (2002) highlighted rework as a major factor adding to cost escalations and time delays in construction projects. Other factors indicated by the findings include construction design complexity and additional work due to errors.

4.7.1.3 Stakeholder related factors responsible for increase in the cost of building materials

Constructions stakeholders are representatives of a crew of individuals who, directly or indirectly, have collective beneficial interests in a project (before and at the end of a project); occasionally they can incur huge losses during construction (Smith *et al.*, 2001; Lim & Yang, 2008). Clients are individuals or establishments principally responsible for introducing construction ideas, and outlining project scopes and specifications (Doloi, 2013; Azmy, 2012). Client contribution to design changes is ranked as the primary stakeholder related factor responsible for increase in the cost of building materials (Table 4.6), as this factor has a mean value of 3.28. Change might occur as a result of newly-emerging ideas perceived by the client for the project to fulfil desired functional and socio requirements. Irrespective of the client's reason, change ordered by clients will arguably have an effect on the cost of construction activities, especially major changes. The investigation of Yana *et al.* (2015) revealed that a client is the chief significant factor in the incidence of design changes. Further, the findings of this study show that incorrect construction method and improper planning are others factors under stakeholder related factors. Proper scheduling is essential in project resources utilization, as lack of this will increase the project cost (Eshofonie, 2008)

4.7.1.4 External related factors responsible for increase in cost of building materials

The external factors responsible for increase in the cost of building materials are the factors that are not attributed to individual participants in the construction sector. Proper processes are an absolute necessity for reducing the impact of external factors on cost of building materials. The most notable external factor responsible for increase in the cost of building materials is change in government policies and regulation (mv=3.02). Government legislations (mv=30.1) and lack of substitute for product (mv=3.00) are the next two highest

rated factors responsible for increase in the cost of building materials (Table 4.7). Dlakwa and Culpin (1990: 238) and Adekoya (2003:29) noted government fiscal policies as one of the factors affecting the cost of building materials. Force majeure factors (outbreak of war, hostilities, uprisings, for example) received a low rank because they rarely impinge upon the South Africa construction industry.

4.7.1.5 Effects of increase in the cost of building materials on housing delivery

The analysis of quantitative data collected for this research and reviewed literature depict that increase in the cost of building materials has an effect on affordable housing delivery in the Western Cape of South African. The increase in the cost of building materials poses a significant threat to the construction industry. The findings from the study (Table 4.8) show fluctuation in cost of construction (with mean value of 3.26) as the most notable effect of increase in the cost of building materials on housing delivery. The client and project contractors have been facing serious trials in trying to maintain steady cost projection on construction projects (Akanni *et al.*, 2014). Clearly, cost control during the construction process is important to ensure the success of a project (Nega, 2008).

The findings also indicated that high maintenance cost due to poor workmanship, increase in the cost of repair due to inferior materials used, client expectations pertaining to quality project delivery, and building collapses due to the use of lesser quality materials are all effects of an increase in cost of building materials on housing delivery. Iwaro and Mwashu, (2012) highlighted that workmanship plays an important role in project quality, especially as one of the characteristics of a developed construction industry is in the output of quality buildings and structures (Lam *et al.*, 2007). However, Oyedele and Tham (2006:2091) posit that lack of significant consideration for design constructability may cause building collapse during the construction process. Therefore, stakeholder satisfaction and timely project completion are yardsticks for measuring project success in relation to time, quality, scope and cost (Mallak, Patzak & Kurstedt, 1991; Takim, 2009; Pinder, Schmidt & Saker, 2013).

4.7.1.6 Influence of stakeholders in materials selection

The material selection technique is a part of the building process, taking into account that stakeholders are not typically regarded as a part of the process. Takim (2009) and Yudelson (2010) stated that for effective management of construction and to ensure efficiency during construction, a combined project team should accommodate a wide range of stakeholders – client, general contractors, architects, project managers, consultants, engineers and

government agents/commissioning authorities – depending on the complexity of the project. The findings reveal that the client (mv=3.43) has the highest degree of involvement in material selection, followed by architect and designer, technical consultant, project manager, quantity surveyor, in this order respectively (Table 4.9). The client involvement is understandable as the client holds the primary responsibility for estimating the activities during the course of the production process, as well as setting priorities (Akadiri, 2011). The importance of the client can further be reflected by the various ways of influence and exerting pressure on project partakers in order to improve building life cycle performance (Gann & Salter, 2000). The relationship between client and architect (designer) is paramount in creating and carrying out design decisions during the course of the construction. This shows the essential role of clients in influencing designer's environmental strategies.

4.7.1.7 Guidelines to materials selection in construction towards enhancing sustainable building delivery

Selection of sustainable building materials in building projects is an essential decision in sustainability practices. Alibaba (2004:307) and Nasar *et al.* (2003:543) highlighted that one of many factors impacting the sustainability of building delivery is precisely this: the selection of building materials. One of the simplest ways to incorporate sustainable principles in building projects is by careful selection of sustainable building materials (Akadiri *et al.*, 2013: 113). A number of researchers have delineated guidelines for which considerations are important in selection of sustainable building materials. Based on this information, the study investigated guidelines to materials selection in construction towards enhancing sustainable building delivery, with findings revealing these factors: building design, environmental impacts of materials, material life cycle cost, material functional demands, material market trend demands, technological impact of materials, material structural demands and material efficiency (use of renewable and recyclable materials) (Table 4.10). All these guidelines identified have a mean score of 3, signifying that the respondents agreed that the identified guidelines are significant towards enhancing sustainable building delivery.

4.7.1.8 Sustainable criteria for building materials selection

One of the main objectives of this research was to ascertain the criteria to be considered in the selection of building materials for sustainable housing delivery. The prospect of sustainable construction is enhanced, both to meet society's environmental goals and account for social wellbeing, as well as address the economic impact of building projects. Thus, the criteria chosen should cover all four categories – economic, environmental, social

and technical – to ensure that attention is being given to progress towards sustainability objectives. As noted in an earlier chapter, to develop sustainable housing, housing initiatives must be socially acceptable, economically viable, environmentally friendly and technically feasible (Choguill, 1999). A list of assessment criteria (Table 4.11) was developed, identified under three categories: socio-economic, environmental and technical.

4.7.1.8.1 Socio- economic criteria

Table 4.11 reveals the perception of respondents on socio-economic criteria to be considered in the selection of building materials. Maintenance cost (with a mean value of 3.36) was ranked as the first priority in selection of sustainable building materials. High maintenance costs have intense negative effects on stakeholders and the construction industry as whole (Mbachu & Nkado, 2004). Building maintenance cost can be reduced with a thorough knowledge of building maintenance cost theories (Faremi *et al.* 2015). The findings also reveal health and safety and initial cost as notable priorities to be considered in the selection of building materials. Initial costs have long been a major concern for stakeholders in the building industry (Akadiri, 2011).

4.7.1.8.2 Environment criteria

The finding shows energy consumption, environmental pollution, air quality and low or non-toxicity as the major criteria to be considered in the selection of building materials (Table 4.11). Effective uses of energy help reduce energy intake in buildings and facilities (Sharma & Mehta 2014:82). Material toxicity issues are of paramount importance to all project participants. Akadiri (2011) posited that using low volatile organic compound materials for construction can considerably decrease the emission volatile organic compounds. This has been acknowledged by the industry as a vital factor to any successful project, a significant step to sustainable construction.

4.7.1.8.3 Technical criteria

The findings reveal maintainability (with a mean value of 3.43) as the most significant factor to be considered in the selection of sustainable materials. Maintainability has long been a major concern among architects and designers in the construction industry. Thus, maintenance free buildings are increasingly sought by clients, so as to reduce the running

costs associated with maintaining buildings (Akadiri, 2011). The findings also reveal life expectancy of material in term of strength and durability, fire resistance, and resistance to decay (Table 4.11) as other notable factors to be considered in the selection of sustainable building materials.

4.7.1.9 Project factors

Table 4.12 revealed client preference (with a mean value of 3.55) as factor that determines the nature and type of materials to be selected. The client has a significant impact on the choices made by architects, as the client wields the power to hire (Folorunso *et al.*, 2017). Thus, this suggests that clients have a substantial role to play in the choice of building materials. Complexity of project, budgeted project, cost scope of project and stakeholder expectations are other factors that determine the type of materials to be selected.

Table 4.13: Summary of findings of quantitative data

S/N	CONCEPTS	ISSUED ADDRESSED	FINDINGS
1.0	To identify factors responsible for increase in the cost of building materials that hinders sustainable housing delivery	1.1 Economic related factors	<ol style="list-style-type: none"> 1. Inflation 2. Exchange rate of rand 3. Interest rate 4. Cost of building materials 5. Market condition
		1.2 Site related factors	<ol style="list-style-type: none"> 1. Wastages of building materials by workers 2. Poor site planning prevents easy movement of materials 3. Inadequate infrastructural facilities 4. Unsuitable location for building materials storage
		1.3 Human related factors	<ol style="list-style-type: none"> 1. Cost of transportation and distribution of labour 2. Cost of power supply 3. Cost of labour 4. Cost of plant 5. Communication problem between labourer and supervisors.
		1.4 Design related factors	<ol style="list-style-type: none"> 1. Design changes 2. Additional work due to change in design 3. Wrong method of estimation by quantity surveyor 4. Construction design complexity 5. Additional work due to errors
		1.5 Stakeholder related factors	<ol style="list-style-type: none"> 1. Client contribution to design change 2. Incorrect construction method 3. Improper planning 4. Client demand on high quality project delivery 5. Supplier default
		1.6 External factors	<ol style="list-style-type: none"> 1. Change in government policies

		<ul style="list-style-type: none"> and regulation 2. Government legislations 3. Lack of substitute for product 4. Level of advanced technology 5. Increase in the cost of hiring construction machineries
2.0 To evaluate the effects of increase in the cost of building materials on the delivery of affordable housing	2.1 Effects of increase in the cost of building materials on housing delivery	<ul style="list-style-type: none"> 1. Fluctuation in cost of construction 2. High maintenance cost due to poor workmanship 3. Increase in the cost of repair due to inferior materials used 4. Poor workmanship 5. Affect client expectation on quality project delivery
3.0 To ascertain the criteria to be considered in the selection of building materials for sustainable affordable housing delivery	3.1 Influence of stakeholders in materials selection	<ul style="list-style-type: none"> 1. Client 2. Architect and designer 3. technical consultant 4. Project manager 5. Quantity surveyor
	3.2 Guidelines to materials selection in construction towards enhancing sustainable building delivery	<ul style="list-style-type: none"> 1. Building design 2. Environmental impacts of materials 3. Material life cycle cost, 4. Material functional demands 5. Material market trend demands
	3.3 Socio-economic criteria,	<ul style="list-style-type: none"> 1. Maintenance cost 2. Health and safety 3. Initial cost 4. Disposal cost 5. Aesthetics
	3.4 Environmental criteria	<ul style="list-style-type: none"> 1. Energy consumption 2. Environmental pollution 3. Air quality 4. Low or non-toxicity 5. Sound disposal options
	3.5 Technical criteria	<ul style="list-style-type: none"> 1. Maintainability 2. life expectancy of material (strength, durability) 3. Fire resistance 4. Resistance to decay 5. Energy saving and thermal insulation
	3.6 Project factors	<ul style="list-style-type: none"> 1. Client preference 2. Complexity of project 3. Budgeted project cost 4. Scope of project 5. Stakeholder expectation

4.8 Validity assurance of the quantitative research results

This section was conducted to assess the validity of the quantitative data obtained by the questionnaires. Basically, the validity assurance of research results shows how applicable the obtained results are in the field of study. Thomas and Magilvy (2011) established that the validity of research is the level to which the data acquired evaluates accurately that which it was intended to measure. To ensure that the research results are valid and reliable, the following steps were considered:

a. *Research population*: The population sampled for this study included construction stakeholders in the construction industry in the Western Cape of South Africa. This population was identified for achieving reliable results (Section 4.3).

b. *Expected participants*: Experienced construction stakeholders within the industry are the targets (Section 4.3 & Table 4.1).

c. *Sampling technique*: The cluster sampling method was adopted for data collection in this study as the use of cluster sampling redistributes the target population (with high concentration of construction companies and experienced professionals) into smaller groups (clusters) from which samples are randomly selected for data collection and result generalisation (Section 3.7.4).

d. *Time*: The data were collected with a considerable time limit.

e. *Data collection instrument*: The most accurate data collection tool was adopted for each phase of collection (Section 3.7.1 and Section 4.1).

f. *Exploratory/pilot study*: The exploratory study was conducted to determine the reliability and accuracy of the data collection method to be adopted for the main study (Section 3.7.2 and 4.2).

g. *Cronbach's alpha co-efficiency analysis*: The Cronbach's alpha co-efficient analysis was conducted to test the reliability of the quantitative research question in this study (Section 4.3).

h. *Interview sessions*: The interview sessions with the respondents were recorded using a mobicel mini ipad smart recorder and analysed using the statistical package software (SPSS, version 24).

4.9 Validation of findings

The qualitative collection phase adopted the construct validity technique. *Construct validity* is a technique adopted to ensure that the findings obtained in this research measure what the study claimed to measure. The findings from the quantitative data analysis were framed into interview questions to confirm if the quantitative results answered what was intended in regard to the research aim and objectives. Three (3) construction organisations were selected for the interview. The researcher scheduled appointments for each interview with the respondents to ensure efficient research time management. Four (3) constructional professional were interviewed on construction sites A, B, and C. The interview session

conducted with each interviewee started with an introduction of research title and explanation of the underlying purpose of the study. The interview was then recorded with a device and subsequently transcribed. A copy of the interview questions is found in Appendix B

Table 4.14: Demographic of qualitative respondents

Respondent	Qualification	Position	Years of experience in construction industry	Years of experience in the present position
A	Bachelor's degree	Site supervisor	12 years	8 years
B	Honour's degree	Project manager	22 years	9 years
C	Bachelor's degree	Site supervisor	14 years	5 years

Interview with respondent A

The first interview was conducted on July 17, 2017, at 16h00min. An experienced project manager who is presently working in the public sector of the construction industry was interviewed. The site supervisor interviewed holds a Bachelor's degree with twelve (12) years' work experience in the construction industry and eight (8) years of experience in the present position. The interview lasted for forty one minutes as the interviewee responded to each interview question with enthusiasm. The interview discussion was recorded using a 'Smart recorder app' installed on mobile iPad mini. A copy of the interview outline is found in Appendix B. The respondent stated the following:

- Inflation and interest rate under the economic related factors are the most significant factors responsible for increase in the cost of building materials.
- The process involved in building production plays a significant role in the cost of building materials, especially considering the poor site planning, wastage of materials by workers and wrong method estimation prepared by some quantity surveyors.
- External factors such as climate changes in weather condition and natural occurrences could also be responsible for an increase in the cost of building materials.
- From experience, a common effect of increase in the cost of building materials is fluctuation; that is, in the sense that when material prices are not stable due to inflation, the contract or construction sum fluctuates, thereby affecting timely housing delivery to the populace.
- Conflict between client and contractor is also an effect of increase in the cost of building materials. Increase in the contract sum easily leads to disputes between involved stakeholders, leaving some disgruntled and dissatisfied.

- When selecting building materials for sustainable building delivery enhancement, building design and specification, environmental impact of materials, material efficiency and market trends are key guidelines which to be cognisant.
- To my own knowledge, different stakeholders have different criteria for selecting building materials depending on the client choice and budgeted project cost and complexity of the project. However, in my opinion, the following could be considered as selection criteria: durability of materials, health and safety, aesthetics, environmental pollution, low or non-toxicity, maintainability and material availability.
- In my own opinion, different measures from different perspectives can be taken to enhance sustainable housing delivery. Government should ensure stable and viable regulations of the cost of building materials. Maintenance practices should be adhered to by suppliers, transporters and end users of building materials. There should be accessible road network from the loading site to the offloading site so transportation cost would be minimal. Materials should be produced with the most affordable and sustainable products, thereby end users can purchase at optimum cost while at the same time enjoying best value for money on the materials. Sustainable practices should be implemented in all facets of building production in the construction industry, including manufacturers, suppliers, workers and end users. If possible, construction activities should be insured, thereby minimising risk of uncertainty.

Interview with respondent B

The second interview was conducted on July 20, 2017, at 13h05mins. The interview was conducted with an experienced project manager who is presently working in the public sector of the construction industry. The project manager interviewed holds an Honour's degree with twenty-two (22) years' work experience in the construction industry and nine (9) years of experience in the present position. The interview lasted for about forty five minutes as the interviewee responded to each interview question after being read out by the interviewer from the interview guideline. The interview discussion was recorded using a 'Smart recorder app' installed on mobicel iPad mini. A copy of the interview outline is found in Appendix B.

- The respondent opined that inflation and exchange rate of Rand to other foreign currencies are factors responsible for increase in the cost of building materials. The respondent further stated that some building materials are being imported from other countries in a quest to meet client demand and expectation on specifically requested building materials which are not available here in South Africa.

- Building production phase is a vital phase which requires proper planning and effective communication. Lack of planning and poor communication between supervisor and labourers can lead to increase in cost of building materials due to waste of construction materials by labourers.
- The respondent further stated other factors responsible for increase in the cost of building materials are additional works due to error in the drawing and client contribution to change in the design. All these factors will automatically result in change in the design.
- Constant changes in government regulations and lack of substitutes for some building materials are the external factor responsible for increase in the cost of building materials.
- In my own opinion and experience in the construction industry, effects of increase in the cost of building materials are construction cost escalation, final cost production higher than budgeted and poor workmanship which in turn leads to high maintenance and repair cost.
- The respondent further stated that an increase in the cost building materials has an adverse effect on client expectation of quality project delivery. In order to avoid conflict between clients and contractors, some contractors use substandard quality materials to meet the client budget requirement, and in this manner impact the client expectations of quality.
- In my own opinion, some guidelines that we should be aware of when selecting building materials towards sustainable housing delivery are material life cycle cost, building design, socio-economic impact of materials and environmental impact of materials.
- The respondent stated that selection of material depends on the client preference, scope of project and project cost budgeted. The respondent identified these criteria: maintenance cost, fire resistance, strength of the materials, health and safety, maintainability energy saving and thermal insulation.
- The project manager advised that the use of sustainable locally made building materials, rather than sophisticated building materials and techniques that are costly and energy consuming, should be encouraged by government as this will enhance affordable housing delivery. This will make the material cost effective and produce sustainable housing provisions. The project manager counselled that in order to enhance sustainable housing delivery, stakeholders should ensure proper monitoring, planning and controlling of the project at all stages during production to

avoid increases in construction costs that are always categorized as project delivery that is above budgeted cost.

Interview with respondent C

The third interview was conducted on July 31, 2017, at 13h25mins. The interview was conducted with a construction site supervisor. The site supervisor interviewed holds a Bachelor's degree with fourteen (14) years' work experience in the construction industry and eight (8) years of experience in the present in the position. The interview lasted for about 40 minutes as the interviewee responded to each interview question after being read out by the interviewer from the interview guideline. The interview discussion was recorded using a 'Smart recorder app' installed on a mobicel iPad mini. A copy of the interview outline is found in Appendix B.

- The respondent stated that economic instability of the country is a contributory factor of the cost increase of building materials. The respondent further stated that price stability depended on the economic situation. However, the price of building materials has been vacillating, which can be attributed to inflationary trends. Interest rate charged by banks is also a factor responsible for increase in cost of building materials under economic factors.
- The respondent opined that building production processes involved the use of manpower. Cost of transportation of labours, cost of labour and wastages of building materials on site by labourers are factors responsible for increase in the cost of building materials.
- The site supervisor further claimed lack of communication between the labourers and stakeholders involved on site as another factor responsible for increase in cost of building materials. The respondent explained that team work practices are a major aspect of handling the building production process; this helps to achieve project objectives and the delivery of a project at budgeted cost, time and quality expected.
- The site supervisor stated that the meeting client expectation during the production process begins from the design stage, after the client briefing. Failure by the design team to incorporate client requirements into design detailing will be conveyed to the preparation of the bill of quantity, which then impacts budgeted costs.
- As for external factors responsible for increase in the cost of building materials, the respondent said that force majeure rarely happens in South Africa as in other countries, though when something occurs, it does affect cost building materials due to deterioration and destruction of some materials. The respondent further said that

government regulations and policies play a significant role in the economic instability of cost of building materials.

- The respondent stated that increase in the cost of building materials has a massive effect on the timely delivery of housing. Building materials consume up to 60% of all construction costs. He further stated that increase in the cost of building materials will push the cost of construction higher than estimated project cost.
- Another effect, with my experience in the industry, is conflict between client and contractor due to the increase in project budgeted cost and delay in the progress of project works. The respondent further noted that late delivery of materials to site is the major cause of construction cost and time overrun.
- The respondent identified some important guidelines to be followed when selecting building materials: it is important to cognisant of economic, environmental and technological impacts on materials.
- In my own knowledge, criteria for selecting building materials differ depending on the type of project involved. However, in my opinion, the following could be considered as selection criteria: durability of materials, health and safety, aesthetics, environmental pollution, ease of construction, maintainability and energy consumption.
- The respondent explained that in order to enhance sustainable housing delivery, some steps must be established. The availability of materials on site is very important, as this determines the speed at which the work is completed and will reduce materials wastage and cost towards economic sustainability. Sustainability should be encouraged and practiced in all phases of building production. Government should enact some regulations that will govern the prices of building materials so as to prevent any manipulation from materials supplier due to high demand of these materials. He further stated that government should pay particular attention to cost of transport, crude cost and energy cost for the efficient and effective distribution of the products from suppliers to end-users.

Table 4.15: Summary of qualitative interviews

Factors	Respondent A	Respondent B	Respondent C
Factors responsible for increase in the cost of building materials	Inflation and interest.	Inflation and exchange rate of rand to others foreign currencies.	Inflation and interest
Building production processes responsible for increase in the cost of building materials	Poor site planning, wastage of materials by workers and wrong method estimation prepared by quantity surveyor.	Waste of construction materials by labourers, design changes and communication problem between labourers and supervisors.	Cost of transportation of labours, cost of labour, wastages of building materials on site by labourers and lack of communication between labourers and supervisors
External factors responsible for increase in the cost of building materials	Climate changes in weather condition and natural occurrences	Change in government regulations and lack of substitute for some building materials	Change in government policies and regulation
Effects of building materials cost on housing delivery	Fluctuation in the cost of construction and conflict between client and contractor	Construction cost escalation, final cost of production higher than budgeted and poor workmanship which will in turn leads to high maintenance and repair cost	Conflict between client and contractor due to the increase in project budgeted cost and delay on the progress of project works
Guidelines that need to be followed or adopted when selecting building materials	Building design and specification, environmental impacts of materials, materials efficiency and market trends	Life cycle cost, building design, socio economic impact of materials and environmental impact of the materials	Economic impact of materials, environmental and technological impact of materials
Criteria for the selection of building materials	Durability of materials, health and safety, aesthetics, environmental pollution, low or non-toxicity, maintainability, and material availability	Maintenance cost, fire resistance, strength of the materials, health and safety, maintainability energy saving and thermal insulation.	Durability of materials, health and safety, aesthetics, environmental pollution, ease of construction, maintainability and energy consumption
Measures that can be taken to enhance sustainable housing delivery	Government should ensure stable and viable regulation of cost of building materials.	Adoption in the use of sustainable locally made building materials	Availability of materials on site this determines the speed at which the work is completed, reduce materials wastage and cost towards economic sustainability

4.10 Achieving the objectives of the research study

The first objective of this study concerned examining factors responsible for increase in the cost of building materials. In achieving the objective, the data collected were analysed and the major findings were centred on economic related factors, building production process related factors, stakeholder related factors and external related factors. Inflation, exchange

rate of rand, interest rate, cost of building materials, market conditions, fluctuation in the cost of raw materials, local taxes and supply and demand of building materials are significant economic related factors responsible for increase in the cost of building materials, as presented in Table 4.4.

The findings also show building production process related factors that are responsible for increase in the cost of building materials. This was comprised of three sub-questions regarding building production process related factors responsible for increase in the cost of building materials. The objective was achieved through the investigation of site related factors, human related factor and design related factors, presented in Table 4.5. Achieving the objective, the findings obtained after data analysis under site related factors are as follows: wastages of building materials by workers, poor site planning preventing easy movement of materials, inadequate infrastructural facilities and unsuitable location for building materials storage. Major findings under human related factors are as follows: cost of transportation and distribution of labour, cost of power supply, cost of labour, cost of plant and communication problems between labourer and supervisors. Under design related factors, the findings are as follows: design changes, additional work due to change in design, wrong method of estimation by quantity surveyor, construction design complexity, additional work due to errors, design team experience and inadequate coordination among design team.

In terms of the impact of stakeholder related factors on increase in the cost of building materials, findings in Table 4.6 shows that client contribution to design change, incorrect construction method, improper planning, client demand on high quality project delivery, supplier default and delay in the supply of materials on site are stakeholder related factors responsible for increase in the cost of building materials. Finally, this study investigated the external related factors responsible for increase in the cost of building materials. Achieving this objective, the finding obtained after data analysis, in Table 4.7, are as follows: change in government policies and regulation, government legislations and lack of substitute for product are the external related factors responsible for increase in the cost of building materials.

The second objective of this study was to evaluate the effects of increase in the cost of building materials on the delivery of affordable housing. The objective was achieved and findings obtained are as follows in Table 4.8: fluctuation in cost of construction, high maintenance cost due to poor workmanship, increase in the cost of repair due to inferior materials used, poor workmanship, impact of client expectation on quality project delivery, building collapse due to the use of less quality materials, conflict between client and

contractor due to upward review of contract sum, delay on the progress of project works, poor quality of construction product, increase in final cost of building products, final cost of production higher than budgeted, high rate of contractor fraudulent practices, low income earners priced out for home ownership due to high cost of building, impact on the aesthetic value of building product, shortage in the delivery of housing to the populace, the gross domestic product (GDP) contribution to the economy, investment return on construction project delayed, and threatening health and safety of workers on site. These are the significant findings of concerning the effects of increase in the cost of building materials on the delivery of affordable housing.

The third objective of this study was to ascertain the criteria to be considered in the selection of building materials for sustainable affordable housing delivery. In achieving this objective, the data collected were analysed and the major findings were centred on the influence of stakeholders in material selection, guidelines for materials selection in construction towards enhancing sustainable building delivery, sustainable criteria to be considered for building materials selection and project factors in the selection of building materials for sustainable housing.

The findings in Table 4.9 show that client, architect, designer and technical consultant are the stakeholders who have a significant influence in the selection of sustainable building materials for affordable housing. Other major findings, presented in Table 4.10, also show that building design, environmental impact of material, material life cycle cost, material functional demands, and material market trend demands, technological impact of materials, material structural demands, and material efficiency are guidelines to material selection in construction towards enhancing sustainable building delivery.

However, the findings also show the criteria to be considered in the selection of sustainable building materials under the sustainability categorised. This is comprised of three sub-questions under the sustainability criteria. The objective was achieved through the investigation of socio-economic criteria, environmental criteria and technical criteria. Achieving the objective, the findings obtained after data analysis, as presented in Table 4.11, are as follows: maintenance cost, health and safety, initial cost, disposal cost, aesthetics and labour availability are the socio-economic criteria for selection of sustainable building materials.

Environmental criteria for selection of sustainable building materials were also investigated. Findings show that energy consumption, environmental pollution, air quality, low or non-toxicity, sound disposal options, embodied energy in the material, environmental statutory

compliance, green gas emission and amount of likely wastage in the use of materials are criteria for the selection of sustainable building materials for affordable housing.

This study investigated the technical criteria for selection of sustainable building materials. The findings obtained after data analysis are as follows: maintainability, life expectancy of material (strength, durability), fire resistance, resistance to decay, energy saving and thermal insulation, moisture resistance, ease of construction, material availability and sound insulation are criteria for the selection of sustainable building materials for affordable housing.

Other major findings also show project factors that determine selection of sustainable building materials. The findings obtained after data analysis, as presented in Table 4.12, are as follows: client preference, complexity of project, budgeted project cost, scope of project, stakeholder expectation, project schedule, project size, site condition, nature of the project and type of project are factors that determine selection of sustainable building materials for affordable housing.

Objective five of this study is to establish solutions to factors causing increase in the cost of building materials towards sustainable affordable housing delivery. The objective was achieved through the identified factors that are responsible for increase in the cost of building materials; through the identified economic related factors, building production process related factors, stakeholder related factors and external related factors, effects of increase in the cost of building materials on the delivery of affordable housing, criteria to be considered in the selection of sustainable building materials for affordable housing; through the assessment of the influence of stakeholders in materials selection, guidelines to materials selection in construction towards enhancing sustainable building delivery, sustainable criteria to be considered for building materials selection and project factors in the selection of sustainable building materials for affordable housing. The findings derived from the analysed data are illustrated in Tables 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11 and 4.12. The findings were used to establish solutions to factors causing increase in the cost of building materials towards sustainable housing delivery. A summary of the key findings is presented in Figure 4.6.

4.11 Operational framework

Figure 4.6 presents the operational framework to enhance sustainable housing delivery. Adequate application of the recommendations presented in this study will significantly

reduce factors causing increase in cost of building materials on housing delivery, and construction time and cost overruns, and ultimately, increase stakeholder satisfaction.

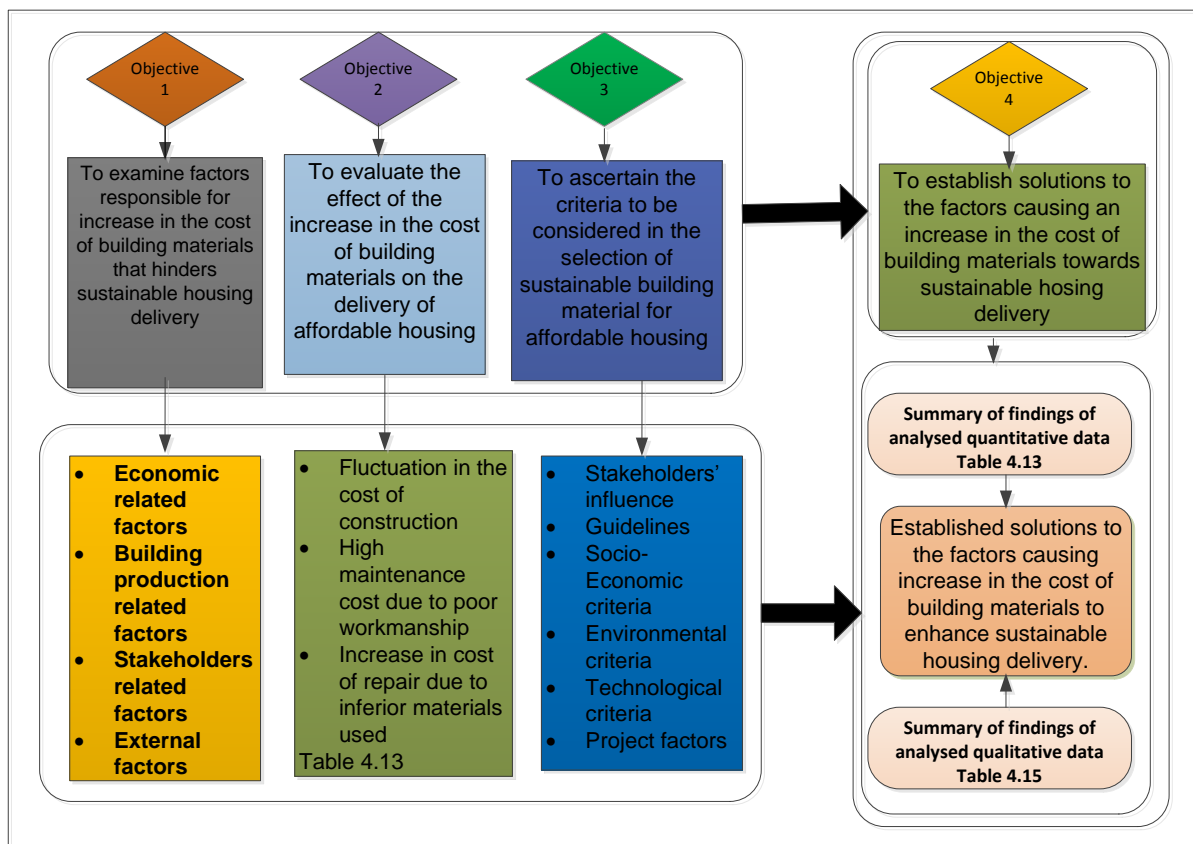


Figure 4.6: Operational frameworks for enhancement of sustainable housing delivery

4.12 Chapter summary

This chapter presents an analysis of data, along with a presentation and discussion of findings. The data collected were analysed using the Statistical Package for Social Sciences (SPSS) software, version 24. Descriptive statistics were used in the study. The survey questions were scaled and tested for reliability using Cronbach's alpha coefficient. The average Cronbach's alpha coefficient for the questions was 0.8, indicating that the questions are reliable.

The findings revealed that inflation, exchange rate of rand and interest rate are the significant economic related factors responsible for increase in the cost of building materials. Wastages of building materials by labourers cost of transportation and distribution of labour and design changes are the major site, human and design related factors responsible for increase in the cost of building materials. Client contribution to change is a key stakeholder

related factor responsible for increase in the cost of building materials. Respondents indicated that change in government policies and regulation, government legislations and lack of substitute for products are the important external related factors. The interview respondents agreed that the effects of increase in the cost of building materials on housing delivery is due to fluctuation in the cost of construction. The findings also revealed that high maintenance cost due to poor workmanship, increase in the cost of repair due to inferior materials and poor workmanship are major effects of increase in the cost of building materials.

Respondents indicated that the client has a significant influence on material selection. The findings revealed that building design, environmental impact of materials and material life cycle cost are guidelines of which to be cognisant when selecting building materials. Major sustainability categories (socio-economic, environmental and technical criteria) to be considered for selection of building materials are maintenance cost, energy consumption and maintainability. The findings also revealed client preference, complexity of project and budgeted project cost are factors determining sustainability criteria for selection of building material for enhancement of sustainable housing delivery in Western Cape in particular, and South Africa in general.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The data derived from the quantitative and qualitative survey on this – ‘effect of building materials cost on housing delivery towards sustainability in Western Cape, South Africa’ – were analysed and discussed. Conclusions and recommendations were made based on the obtained results. This study aimed to investigate the effects of building material cost on the delivery of affordable housing towards sustainability in the Western Cape, South Africa. The objectives of this study were as follows:

1. to examine factors responsible for increase in the cost of building materials that hinder sustainable housing delivery;
2. to evaluate the effects of increase in the cost of building materials on the delivery of affordable housing;
3. to ascertain the criteria to be considered in the selection of building materials for sustainable affordable housing; and
4. to establish solutions for factors causing increase in the cost of building materials towards sustainable affordable housing delivery.

5.2 Summary

Based on the literature reviewed and findings obtained through mixed method of data collection, Table 5.1 presents the summary of research outcomes.

Table 5.1: Summary of research study

S/N	Concept	Reference	Page
I.	Conceptual framework	Figure 1.1	4
.	Research method	Figure 3.3	64
	Summary findings of quantitative study	Figure 4.13	88
	Summary findings of qualitative study	Figure 4.15	96
	Operational framework for the study	Figure 4.6	100

5.3 Conclusion

The adoption of these findings by construction stakeholders in the South African construction industry would enhance the delivery of affordable housing whose process of construction and life cycle of operation would promote healthy well-being of the occupants and environmental stability, at reduced cost, required time and expected quality. Considering the objectives of this study, these factors were discussed and achieved.

5.3.1 Factors responsible for increase in the cost of building materials that hinder sustainable housing delivery

One of the objectives designed to achieve the purpose of this study is to identify factors responsible for increase in the cost of building materials that hinder sustainable housing delivery. This objective was achieved through the review of literature, exploratory study, and administration of survey questionnaires to construction stakeholders and semi-structured interviews with site supervisors. All the identified factors attracted more than a 50% agreement rate from respondents. Therefore, it can safely be concluded that the majority of the identified economic related, building production process related factors, stakeholder related factors and external factors are significant factors responsible for increase in the cost of building materials that hinder sustainable housing delivery in the Western Cape of South Africa. Nonetheless, the most influential factors responsible for increase in cost of building materials are essential to be noted, if improvement in cost effectiveness is to be achieved.

5.2.3 Effect of increase in the cost of building materials on the delivery of affordable housing

The second objective of the study is to evaluate the effects of increase in the cost of building materials on the delivery of affordable housing. This objective was achieved through a review of relevant literature, an exploratory study, and administration of survey questionnaires to construction stakeholder, along with semi-structured interviews with site supervisors. Twenty three (23) factors were investigated. Findings reveal that fluctuation in the cost of construction was identified as a major effect of the increase in the cost of building materials on the delivery of affordable housing in Western Cape. The findings also revealed high maintenance cost due to poor workmanship and increase in the cost of repair due to inferior materials used as two others effects of increase in the cost of building materials on housing delivery in Western Cape of South Africa.

5.3.3 Criteria to be considered in the selection of sustainable building materials for affordable housing

Twenty nine (29) factors were identified as criteria to be considered in the selection of sustainable building materials. These factors were further sub-divided into socio-economic criteria, environmental criteria and technical criteria based on sustainability. This objective was achieved through the review of relevant literature, the exploratory study, the administration of survey questionnaires to construction stakeholder and semi-structured interviews with site supervisors. The findings revealed maintenance cost as key socio-economic criteria to be considered when selecting building materials. Findings also reveal energy consumption as significant environmental criteria to be considered, and maintainability as the key technical criteria to be considered in the selection of sustainable building materials for affordable housing.

Effective consideration of building materials before selection in construction towards enhancing sustainable housing delivery based on socio-economic, environmental and technical criteria is a method to ensure that the sustainability supply chain requirements are met at the initial phase of the project. This would allow construction stakeholders to verify that the building production processes abide by the principles of sustainability from the early stages of the building.

5.4 Limitations

This study was conducted in the Western Cape Province of South Africa. The collection of data from construction stakeholders and contractors was a challenging task in the course of the study as a result of the busy schedules of the respondents. The majority of the respondents complained of their tight time schedules on site, attending contract meeting and the pressure on them to meet certain project completion time. Some stakeholders on construction sites complained of not having the time to answer any questions, and such refusal to assist with this project tended to produce similar responses from their colleagues working in the same office. Due to time constraints, a significant number of the questionnaires were returned incomplete and therefore discarded by the researcher. As a result, the findings of the study are only applicable to construction operations in the Western Cape and cannot be generalised.

5.5 Conclusion and recommendations

The examined findings that are responsible for increase in the cost of building materials during a production process, if effectively considered by stakeholders during the production process, will improve delivery of a project at construction budgeted costs satisfactory to the client. Increase in the cost of building materials has been narrowed down to economic instability of this country. This has a significant impact on the manufacturer of building materials, due to high cost of raw materials, forcing the manufacturers to increase cost of building materials when produced. In order to provide lasting solutions, and bring about steady building material prices and avoid circumstances of constant price increases, the government should assemble building material monitoring committee that will bring innovations in construction methods and materials research. Quarterly material research will help curb the continuous increases in building material price. Government should support and encourage the conducting of innovative research in the development of new local building materials for production; this will reduce the reliance on expensive imported materials.

Wastages of building materials by workers is a site related factor responsible for escalating costs of building materials. This could be a result of the lack of communication between the involved stakeholders and site workers and lack of material management. Construction stakeholders are required to incorporate practical knowledge acquired in the industry and intelligent management skills to effectively communicate about the project with site workers. Additionally, effective material procurement management is required to avoid wastage of building materials during building production process. Moreover, timely delivery of building materials to site enables the effective usage of materials during construction and reduces material wastages during production processes. Cost of transportation and distribution of labour are the human related factors responsible for increase in the cost of building materials. These are enormous challenges within the industry and require necessary measures to curb the waste. Government should also take drastic measures to counter the problem of transportation costs, cost of power supply, and increase in the fuel prices, to improve ease of movement and distribution of raw materials to the factory as well as distribution of the finished products from the factory to the end-user. Therefore, it is recommended for proficiency and effective distribution of the finished products from factory to suppliers and end-users, that the South African government develop long-lasting highways and introduces high speed trains for transportation of goods and services which include building materials.

Change in design is the identified top design related factor that is responsible for increase in the cost of building materials. A change in design could result from design specification obscurity, errors, omissions and changes ordered by client. This could be avoided through the procurement of experienced architects and engineers from as early as the conceptual phase. To achieve effective design, objectives must be clearly presaged by the client to the designer at the conceptual phase, ensuring that client requirements are met while still maintain timely project delivery.

This study showed fluctuation in construction as a top effect of increase in the cost of building on housing delivery. In order to diminish excessive fluctuation in the cost of construction, Desai and Desale (2013) suggested that stakeholders should have a well-developed plan for materials, in advance, to avoid the effect of increase in building materials prices in the market. Thus proper planning and scheduling at the initial stages of construction is essential; this includes early purchase of building materials within the budgeted cost and suitable storage of building materials to avoid cost overrun, disputes and inflation. This will enhance timely delivery of housing at the budgeted cost while meeting client expectations.

The delivery of sustainable housing entails the ability to meet the present housing needs of humans without obliging on the capacity of the future generation to meet their own needs. Hence, the enhancement requires major resources (materials, machinery and manpower), and criteria carefully considered by construction stakeholders for a successful project delivery. Proficient consideration of several criteria in material selection will ensure sustainable development in building design and construction. Maintenance cost, energy consumption and maintainability are significant criteria to be considered in the selection of sustainable building materials to enhance delivery of affordable housing. Thus, effective consideration of building materials *before* selection in construction towards enhancing sustainable housing delivery based on socio-economic, environmental and technical criteria is a framework to ensure that sustainability supply chain requirements are met from the very beginning of the project.

The study concluded that proper consideration of these findings obtained in the study will aid the development of the framework, presented in Figure 4.6, as an advantageous model to be operationalised on Western Cape construction sites. Adequate application of the recommendations presented in this study will significantly enhance sustainable housing delivery that is cost-efficient, at expected qualities, within a specified time and affordable.

5.6 Areas for further study

This research study recommends, among other issues, to search and develop new sustainable building materials and technologies applicable to the South African construction industry.

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APPENDICES: APPENDIX A – SURVEY QUESTIONNAIRE



EFFECT OF BUILDING MATERIALS COST ON HOUSING DELIVERY TOWARDS SUSTAINABILITY

Dear Sir/Madam,

PARTICIPATION IN A SURVEY

You are cordially invited to participate in this research survey which aims to investigate the effects of building materials cost on the delivery of affordable housing towards economic sustainability. This study is primarily undertaken for academic purposes for a Master of Technology degree in Construction Management at Cape Peninsula University of Technology.

All information provided in this study will be kept strictly **CONFIDENTIAL**.

Kindly complete the survey and return to:

Bimpe Alabi,

E-mail: alabim2010@yahoo.com

Department of Construction Management and Quantity Surveying

Mobile: +27 (0) 78 460 3649

Thanks for your cooperation and readiness to assist always.

Please tick as appropriate

1. I am aware that the information required by the researcher for in this study and it is perceived as an opportunity to contribute towards sustainable building innovation.

2. I understand my participation is voluntary and that I am permitted to withdraw at any point in the survey.

3. I hereby endorse my participation in the research survey

Participant Date.....Signature.....

Name (optional).....

Bimpe Alabi Date.....Signature.....

QUESTIONNAIRE

SECTION A: BIOGRAPHICAL INFORMATION OF PARTICIPANTS

PLEASE, cross or tick as appropriate (X or √) to indicate your opinion.

A1. Kindly indicate which best describes your company:

Project management firm	
Contracting firm	
Materials supplier	
Construction managing firm	
Government establishment	
Quantity Surveying consulting firm	
Others (Specify)	

A2. Please indicate your gender:

Male	
Female	

A3. Please indicate your age group:

Below 26	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	65 Above

A4. Please indicate your highest formal qualification

Matric Certificate	Diploma	Bachelor's/ Honour's degree	Master's degree	Doctorate degree	Other (please specify)

A5. Kindly indicate your present position in your firm.....

A6. How long have you been working in this position?

A7. Kindly indicate the number of years of work experience you have.....

SECTION B: FACTORS RESPONSIBLE FOR THE INCREASE IN THE COST OF BUILDING MATERIALS

B1. The following are **economic related factors** responsible for the increase in cost of building materials, kindly **“tick as appropriate”**, using the scale below.

Where: 4 = Strongly agree, 3= Agree, 2= Disagree, 1= Strong disagree,

ECONOMIC FACTORS	4	3	2	1
Exchange rate of rand				
Inflation				
Interest rate				
Local taxes and charges				
Fluctuation in the cost raw materials				
Inadequate production of building materials				
Supply and demand of building materials				
Cost of building materials				
Scarcity of building raw materials				
Market condition				

B2. The following are **Building production processes related factors** responsible for the increase in cost of building materials, kindly **“tick as appropriate”**, using the scale below.

Where: 4 = Strongly agree, 3= Agree, 2= Disagree, 1= Strong disagree,

BUILDING PRODUCTION PROCESSES	4	3	2	1
SITE RELATED FACTORS				
Poor site planning prevents easy movement of materials				
Unsuitable locations for building materials storage				
Wastage of building materials by labourers				
Pilferage of materials on site				
Inadequate infrastructural facilities				
Shortage of building materials on site				
Cost of fuel				
HUMAN FACTORS	4	3	2	1
Cost of transportation and distribution of labour				
Communication problem between labourers and supervisors				
Cost of labour				
Cost of power supply				
Delay in payment of construction labourers				
Cost of fuel				
Cost of plant				
Lack of discipline among labourers				
DESIGN FACTORS	4	3	2	1
Design changes				
Additional work due to errors in design				
Additional work due to changes in design				
Construction design complexity				
Inadequate coordination among design team				
Wrong method of estimation by quantity surveyor				
Design team experience				

B3. The following are **stakeholders' related factors** responsible for the increase in cost of building materials, kindly **"tick as appropriate"**, using the scale below.

Where: 4 = Strongly agree, 3= Agree, 2= Disagree, 1= Strong disagree,

STAKEHOLDERS 'RELATED FACTORS	4	3	2	1
Delay in the supply of materials				
Change initiated by contractor to improve quality				
Inadequate details in drawing				
Fraudulent activities				
Improper planning				
Client demand on high quality project delivery				
Client contribution to design change				
Supplier default				

B4. The following are **external related factors** responsible for the increase in cost of building materials, kindly **"tick as appropriate"**, using the scale below.

Where: 4 = Strongly agree, 3= Agree, 2= Disagree, 1= Strong disagree

EXTERNAL FACTORS	4	3	2	1
Force majeure (natural occurrences)				
Weather condition				
Political interference				
Change in government policies and regulation				
Lack of substitute for product				
Level of advanced technology				
Effect of rainfall on building materials				
Poor nature of construction site				
Increase in cost of hiring construction machineries				
Government legislations				

SECTION C: EFFECTS OF INCREASE IN THE COST OF BUILDING MATERIALS ON HOUSING DELIVERY.

The following are the **effects of increase in the cost of building materials on housing delivery**. Kindly “**tick as appropriate**” the extent at which it affects delivery of affordable housing

Where 4 = To a very large extent, 3 = To a large extent, 2 = To a little extent, 1 = Not at all

EFFECTS OF INCREASE IN THE COST OF BUILDING MATERIALS ON HOUSING DELIVERY	4	3	2	1
Fluctuation in cost of construction				
Unemployment of construction workers				
Hindered adequate implementation of innovation in construction				
Low volume of construction product				
Poor quality of construction product				
Increase in project abandonment				
Shortage in the delivery of adequate housing to the populace				
Delay on the progress of project works				
Poor workmanship due to inadequate materials to use				
Completion at the expense of other projects				
Building collapses due to the use less quality of materials				
Low income earners priced out of home ownership due to cost of building				
Affect gross domestic product (GDP) contribution to the economy				
High maintenance cost due to the use of less quality materials				
Increase in the cost of repair due to inferior materials used				
Affect the aesthetics value of building product				
High rate of contractors' fraudulent practices				
Threatening health as well as safety of workers on site				
Affect client expectation's on quality project delivery				
Increase in final cost of building product, final cost higher than budgeted				
Transportation cost – e.g. returning sub-standard materials to the supplier				
Investment return on Construction project are delayed				
Conflict between client and contractors due to upward review of contract sum				

SECTION D: CRITERIA FOR SELECTION OF SUSTAINABLE BUILDING MATERIALS

D1. The following are **the stakeholders** in the building industry kindly indicate how much influence each has in materials selection. On a scale of 1 – 4

Where 4 = Very high, 3 = High, 2 = Low, 1 = Very Low

STAKEHOLDERS	4	3	2	1
Client				
Architects & designers				
Quantity Surveyors				
Project Managers				
Site Managers				
Contractors				
Technical consultants				
Suppliers of materials				
materials manufacturer				

D2. The following are **guidelines** to materials selection in construction towards enhancing sustainable building delivery. Kindly rate their level of effectiveness.

Where: 4 = Very Important, 3 = Important, 2 =Not Important, 1 = Less Important

GUIDELINES	4	3	2	1
Environmental impact of materials				
Material market trend demands				
Material life cycle cost				
Material structural demands				
Material functional demands				
Socio economic impact of materials				
Material efficiency (use of renewable and recyclable materials)				
Material overview				
Technological impact of materials				
Building design				

D3. The following are **criteria** often considered during materials selection for optimum materials usage in relation to the sustainability categories under which they are listed. “**Kindly tick as appropriate.**”

Where: 4 = Extremely Important, 3= Important, 2 = Not Important, 1 = Less Important.

SOCIO- ECONOMIC CRITERIA	4	3	2	1
Initial cost				
Maintenance cost				
Disposal cost				
Transportation cost				
Recycle cost				
Health and safety				
Aesthetics				
Use of local materials				
Labour availability				
ENVIRONMENT CRITERIA	4	3	2	1
Air quality				
Potential for recycling as well as re-use				
Environmental pollution				
Sound disposal options				
Green gas emission				
Energy consumption				
Low or non- toxicity				
Amount of likely wastage in the use of material				
Ozone depletion potential				
Environmental statutory compliance				
Embodied energy in the material				
TECHNICAL CRITERIA	4	3	2	1
Resistance to decay				
Fire resistance				
Maintainability				
Sound insulation				
Energy saving and thermal insulation				
Life expectancy of material (strength, durability)				

Material availability				
Ease of construction				
Moisture resistance				

D3. Following are **project factors determine** the nature and type of materials kindly indicate as they affected your rating of the criteria listed above. **“Kindly tick as appropriate.”**

Where 4 = To a very large extent, 3 = To a large extent, 2 = To a little extent, 1 = Not at all

FACTORS	4	3	2	1
Client preference				
Project schedule				
Stakeholder expectation				
Nature of the project				
Budgeted project cost				
Site condition				
Complexity of project				
Size of project				
Scope of project				
Type of project				

THANK YOU VERY MUCH FOR YOUR TIME.

APPENDIX B: INTERVIEW QUESTIONS



1. In your own opinion, what are the factors responsible for the increase in the cost of building materials?
2. Based on your experience, do you opine that building production processes play a role in the cost of building materials?
 - Do external factors play a role on the cost of building materials?
3. In your opinion, what are the effects of building material cost on housing delivery?
4. From your experience, what are the criteria for the selection of sustainable building materials?
5. What guidelines need to be followed or adopted when selecting building materials?
6. In your own opinion, what measures can be taken to enhance sustainable housing delivery with respect to the cost of building materials?