Strategy to enhance sustainability in affordable housing construction in South Africa

by

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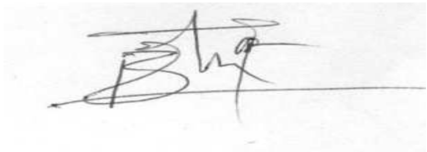
DECLARATION

I, **Bashir Olanrewaju Ganiyu**, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinion and not necessarily those of the Cape Peninsula University of Technology.



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ABSTRACT

South Africa's government is faced with the challenge of providing housing for its citizens, especially the historically disadvantaged population who seek job opportunities and improvement on their life style in urban areas. To achieve this laudable goal, the South African construction industry must be proactive in its approach to the construction of affordable housing, and must adopt construction strategies that enhances sustainable housing development. Born from this challenge is the need for research to establish how sustainable development concepts could be integrated into housing construction processes, with a view to develop strategies to achieve affordable housing that enhances sustainability, to cater for South Africans in need of decent accommodation.

The study developed a conceptual model through extensive review of extant literature; South Africa housing policy and legislation, sustainable construction and development, socio-economic considerations for sustainable building development, and strategies for sustainable building construction amongst other were reviewed. The study adopted a sequential mixed method approach for data gathering, whereby an initial qualitative pilot survey was conducted to test the existence of the research problems identified in this study and to validate the conceptual model constructs. A web survey approach was used for quantitative data gathering by means of a specifically developed questionnaire, which was emailed nationwide to selected general building contractors, architects and staff of the Department of Human Settlement. Data analysis was done using the descriptive statistical technique, correlation and Principal Component Analysis (PCA). The results from the quantitative phase was used to develop an interview guide for the qualitative phase, and multiple case study interviews involving three construction professionals were undertaken. The qualitative data collected through the oral interviews were transcribed and analysed using content analysis. Subsequently, Partial Least Square Structural Equation Modeling (PLS-SEM) was used to develop and validate the Housing Construction Sustainability Enhancement Model developed in this study.

The results revealed, amongst others; that environmental consciousness is important to enhance sustainability of affordable housing for the low income population, low income populations are desirous of housing that supports reduction in operating costs of the building, and consideration of the social-cultural/economic attributes of users in the building design as well as during construction. The results on the housing financing concept that supports the construction of sustainable housing revealed that Down-Payment Grant, Mortgage Payment

Subsidies, Mortgage Interest Deduction and Credit Enhancement are strongly significant in sustainable housing construction. Therefore, merging two or more of these financing concepts will provide a more flexible way to finance affordable housing in a sustainable manner for the benefit of the user. The results of PCA also revealed that economy of construction, contract management, project team expertise, social-environmental influence, and technology and innovation are the factors influencing cost of sustainable housing construction. On the construction methods, the study revealed very strong statistical correlation between Traditional construction method, Modular construction, Concurrent engineering, Lean concept and achievement of project objectives to realise sustainable affordable housing.

On the achievement of social sustainability indicators, the study revealed that infrastructural development, household size, stakeholder engagement, and health and safety are the key indicators to promote sustainable housing construction at the inception stage of the project. At the design stage of housing, reduction in building operating cost, protection of biodiversity and the surrounding natural habitat which influences the socio-economic activities and human interactions, stakeholders' engagement, and provision of facilities that encourage human interactions were revealed as the essential social-sustainability indicators. While at the construction stage, use of locally sourced building materials and labour, community participation, and health and safety were revealed as the most important social indicators. The assertion on these indicators was unconnected with the fact that using locally sourced materials and labour will not only enhance project success but will impact positively on socio-economic well-being of the people.

The housing sustainability enhancement model has been developed using PLS-SEM. The results reveal that the construction method, social sustainability indicators and housing financing systems have high predictive capabilities to influence the construction of affordable housing that would satisfy building owners' requirements, minimise capital cost of construction, minimise building cost in-use and minimise the negative impact of the building on the environment, which was the ultimate goal of sustainability in construction.

The housing sustainability enhancement model developed in this study has created a comprehensive approach that combines both technological aspects (construction method) with non-technological aspects; combining the social and economic aspects of the building process in one model. The findings have provided baseline indicators for construction organisations, housing developers and government agencies to harness both technological and socio-economic parameters to improve the affordable housing construction process.

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DEDICATION

This work is dedicated to my wife, Khadijat Adewumi AbdulGaniyu, my children Maryam, Fatimah, Bashir and Khairat AbdulGaniyu, for enduring all the financial hardship inflicted on them during my pursuit of this degree.

PUBLICATIONS ARISEN FROM THIS THESIS

The following are the articles that emanate from the research during the course of writing this thesis:

Journal articles

1. **Bashir O. Ganiyu**, Julius A. Fapohunda, and Rainer Haldenwang (2016), Sustainable Housing Financing Model to reduce South Africa Housing Deficit. "International *Journal of Housing Markets and Analysis"*, Emerald (article accepted for publication).
2. **Bashir O. Ganiyu**, Julius A. Fapohunda, and Rainer Haldenwang (2016), Empirical analysis of Building construction methods to develop housing sustainability enhancement model. "*Construction Innovation"*, Emerald (article accepted for publication).
3. **Bashir O. Ganiyu**, Julius A. Fapohunda, and Rainer Haldenwang (2016), Empirical analysis of factors influencing cost of sustainable housing construction. "*Journal of Construction Project Management and Innovation"* (article under review).

Conference papers

1. **Ganiyu, B.O**., Fapohunda, J.A. and Rainer H. (2014). Developing sustainable housing for low income class in Western Cape Province: Quality checks on South African government low-cost housing. SACQSP-2014 proceedings of 7th Annual Quantity Surveying Research Conference Organised by South Africa Council for Quantity Surveying Practice (SACQSP), held at CSIR International Convention Centre, Pretoria South Africa 22 – 23 September. ISBN: 978-0-620-61397-2.
2. **Bashir O. Ganiyu**, Julius A. Fapohunda, and Rainer Haldenwang, (2015). Conceptual framework for sustainable affordable housing construction in South Africa. Proceedings of DII-2015 Conference on Infrastructure Development and Investment Strategies for Africa, held at Livingstone Zambia on 16 – 18th September 2015. ISBN: 978-0-86970-782-1.
3. **Bashir O. Ganiyu**, Julius A. Fapohunda, and Rainer Haldenwang (2015), Construction approaches to enhance sustainability of low and medium income housing in developing countries. Proceedings of World Congress on Sustainable Technologies (WCST-2015) Conference, held at Heathrow London on 14th – 16th December 2015. ISBN: 978-1-908320-53-7.

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GLOSSARY

Terms / Abbreviations	Definition / Explanation
Sustainability	"State in which components of the ecosystem and their functions are maintained for the present and future generations"
Sustainable Development	Development which meets the needs of the present without compromising the ability of future generations to meet their own needs
Housing	Group of buildings that are design and build for residential purposes.
Sustainable Housing	Houses designed, built and managed as healthy, durable, using technological low-energy & affordable building materials, properly integrated into socio-cultural & economic fabric of local neighbourhood and wider urban areas and properly run and maintained.
Affordable Housing	Houses that are genuinely sustainable and affordable for all income classes
Informal settlement	Settlement of the urban poor that result from unauthorised occupation of land, with non-adherence to land use and building regulations
Construction	The comprehensive cycle of a building project covering; the design, building and operational stages.
Sustainable Construction	A holistic process aiming to restore and maintain harmony between the natural and built environments, while creating settlements that affirms human dignity and encourages economic equity
RSA	South Africa
UK	United Kingdom
USA	United State of America
UN	United Nation
WCED	World Commission on Environment and Development
GBCSA	Green Building Council South Africa
LCA	Life Cycle Assessment
LEED	Leadership in Energy and Environmental Design
HK-BEAM	Hong Kong Building Environmental Assessment Method
MCDM	Multi Criteria Decision Making Method
DHS	Department of Human Settlement
SPSS	Statistical Package for the Social Sciences
GDP	Gross Domestic Product
cidb	Construction Industry Development Board South Africa
HDI	Historically Disadvantage Individuals in South Africa
FDI	Foreign Direct Investment
BNG	Breaking New Ground Policy on Housing South Africa
SACAP	South Africa Council for Architect Profession
PCA	Principal Component Analysis
SEM	Structural Equation Model

SACPCMP	South African Council for Project and Construction Management Profession
SACQSP	South African Council for Quantity Surveying Profession
SACCEP	South African Council for Civil Engineering Profession
SAIAT	South African Institute of Architect Technologist
CIOB	Chartered Institute of Building
BBBEE	Broad-Based Black Economic Empowerment
HCSEM	Housing Construction Sustainability Enhancement Model

CHAPTER ONE
GENERAL INTRODUCTION

1.1 INTRODUCTION

Every research is undertaken for a specific purpose, and it is necessary to establish the needs for the research and to clearly set out the intentions of the research from the onset. Thus, this chapter sets out the general overview of the study and provides explicit discussion of the background to the research, with the aim and objectives defined. A brief discussion of the scope, overview of research methodology and outline of the structure of the thesis is also presented.

1.2 RESEARCH BACKGROUND

Developing nations are challenged on the future of its settlements, against the backdrop of addressing issues of inadequate housing, rapid urbanisation and lack of infrastructures (du Plessis, 2002:1). The high rate of household formation, due to an increase in population, has resulted in a significant shortage of affordable housing in South Africa (RSA). It has become equally challenging for the government as well as private real estate developers to provide affordable housing to lower and medium income families in urban centres, mainly due to high demand, escalating prices and non-preference to vertical expansion apartments. However, the rise in demand and shortage in supply for housing calls for the need to address issues of affordable housing in RSA to ensure the well-being of the society and a stable and promising future for the country. Rapid population growth and continuous industrialisation in the developed and developing nations together with increasing standards of living have turned the creation of the built environment into a serious threat to the natural environment (Emmanuel, 2004:1255; Ding, 2008:451; Shi, Zuo, Huang & Pullen, 2013:1). Consequently, the bond between the built and the natural environments has received much attention from the academia and has driven new scientific research (Anderson & Shiers, 2002:75). Notable researchers (Ding, 2008:463; Halliday, 2008:61; Shi, *et al.*, 2013:1) have established that construction significantly impacts on the use of natural resources for construction works, and is one of the largest polluters of manmade and natural environments. Hence, there is a great need for improvement in the provision of housing in a way that encourages greater environmental responsibility and places greater value on the welfare of future generations (Ding, 2008:451).

Sustainable development is categorised under the tripod-stand of sustainability; economic, environmental and social. From a social perspective, housing not only provides shelter, but also gives a sense of a secure future and builds up communities (Arman, Zuo, Wilson, Zillante & Pullen, 2009:3034). Maliene and Malys (2009:428) appraise housing from an economic perspective, viewing housing construction as one of the major investments that people make in their lives. According to UN-Habitat (2006), the housing sector contributes about 10% of the global gross domestic product and 7% of global jobs. The consequences, however, are increasing greenhouse gas emissions, depletion of energy and natural resources, waste production, and changes in land-use dynamics (UN Habitat, 2005).

Housing is a basic human need and a key component in the sustainable development of a nation (Dumreicher & Kolb, 2008:319). This important component has however not been significantly developed in affordable-housing markets towards enhancing sustainability. Instead, the focus has been on displaying architecturally well-designed green buildings (Arman, *et al.,* 2009:3040). The demand for housing has grown in recent decades worldwide and is expected to grow continuously (Wood, 2007:78). Heravi and Qaemi (2014:456) stated that the benefits of sustainable buildings are beyond reducing the negative impacts of buildings on public health, but rather reducing its operating cost, improving occupant productivity and facilitating community development. Wallbaum, Ostermeyer, Salzer, and Zea Escamilla, (2012:353) argue that supporting and stimulating sustainable development and the need for sustainable solutions in the construction of affordable housing, is important to curb the growing global demand for housing.

According to Goebel (2007:291), Low-Cost housing provision is high priority for the South African government in post-Apartheid urban South Africa; this is largely due to the need to address historical racial inequalities, poor municipal service provision and contemporary rural urban migration. These policy developments provide some hope for positive change, although still not fully responding to or addressing the dualistic challenge of providing services, in this case housing and amenities, whilst ensuring a safe and sustainable environment. However, South Africa's urban settlements reveal unsustainability in its past, present and projected future (du Plessis & Landman, 2002:4; Goebel, 2007:292).

Construction cost has been the most important consideration for the implementation of any construction project. In the same vein, cost plays a prominent role in decisions on the implementation of sustainable construction (Kunzlik, 2003:185; Meryman & Silman, 2004:217). Ofori and Kien (2004) emphasise the extra cost required in most cases as the main constraint for implementing sustainable construction. Ding's (2008:456) review of sustainable construction environmental assessment tools expresses concerns for non-inclusion of cost parameters for assessment in the sustainable building evaluation framework tools.

Meryman and Silman (2004:217) identify three primary barriers in sustainable construction; economic factors as the most critical barrier, and policies and technical issues are the other barriers. A study by Qi, Shen, Zeng and Jorge (2010:1360) shows managerial concern as the most important driver for the adoption of green practices by contractors. According to research by Qi, *et al.,* (2010), the main barriers of sustainable construction were classified into four aspects, i.e. economics, technology, awareness and management. However, unwillingness of industry practitioners to change the conventional way of specifying existing methods and processes constitute a technical barrier to the adoption of sustainable construction concepts (Chen & Chambers, 1999:681; Meryman & Silman, 2004:218). However, the sustainability of a building depends on the choices of principal roleplayers in the construction process: building owners, managers, designers, contracting firms, and so on. Hence, the pace of actions towards sustainable application depends on the awareness, knowledge as well as an understanding of the consequences of individual actions (Braganca, Mateus & Koukkari, 2007; Abidin, 2010:425).

Considering this barrier, Halliday (2008:173) explains that a pleasant building enriches a community or organisation and improves the ability to learn or increases productivity. This explanation is reinforced by Akadiri (2011:1), that the built environment has a greater influence on the physical and economic health and well-being of individuals, communities and organisations. However, where buildings contribute to ill-health and disaffection, undermine community and create excessive financial liability, such buildings are undesirable and unsustainable (Heravi & Qaemi, 2014:456). Therefore, it is necessary to develop a holistic strategy to be used by developers and government in construction of affordable housing towards enhancing sustainability.

Conversely, increase in the global urban population has resulted in a very sharp increase in the demand for shelter. Unfortunately, the current housing sector cannot cope with the demand for living space (Jenkins, Smith & PingWwang, 2007:155). Meanwhile, this gap between demand and supply creates a complex problem, driving the housing sector towards less efficient and more-expensive solutions, and new city dwellers towards informal (and often illegal) independent construction of buildings (Arman *et al*., 2009:3038). There are many approaches that can be used to solve the problem of unaffordable housing. These include social and cultural aspects, urban development and land use, construction economics and financing which may include facilitating special financial sources, providing free lands, devising policies that promote construction of such housings, and decreasing the construction cost of such housings (Assaf, Bubshait & Al-Muwasheer, 2010:291). There is a need for a corresponding sense of urgency to develop socially responsible housing solutions that can be acquired by low-income family groups within a reasonable period and cost.

Solving the housing problem in South Africa requires a holistic strategy towards building houses that are not just affordable but equally sustainable to both the building provider and the end-users. Thus, this study aims to provide strategies on the use of appropriate construction methods and cost reduction mechanisms during the construction of affordable buildings, in order to achieve sustainable housing.

1.3 PROBLEM STATEMENT

Housing affordability places too much emphasis on the price tag and the upfront cost to be paid to own a house, neglecting the day-to-day running of the building, which eventually detracts attention from long-term sustainability, as defined by the World Commission on Environment and Development (WCED, 1987:43).

Literature has revealed that housing affordability is largely measured by using a simple ratio of building cost to housing consumer's income, and thus fails to show anything about the standard of housing or the environment in which the housing is sited, which was viewed as an inaccurate and unsustainable way to assess affordability (Mulliner, Smallbone & Maliene, 2013:271). Arman, *et al.,* (2009:3038) view affordability and sustainability as two opposing issues since sustainability parameters include, but are not limited to, intergenerational equality, economic feasibility, social acceptability, energy efficiency and waste minimisation. An inefficient building, however, imposes a cost penalty on the client throughout its lifetime. While it is important for clients to minimise whole life costs, the contractors and consultants do not. This is because consultant and contractor do not have a long-term interest in the building and are not accountable for performance in-use (Arman, *et al.,* 2009:3038). However, the assertions of Arman *et al*., (2009:3038) corroborate worries expressed by Ding (2008:456) for non-inclusion of cost parameters for assessment in the evaluation framework tools such as BREEAM, BEPAC, LEED, and HK-BEAM.

However, Shackleton, *et al.,* (2014:501,508) conclude that South African urban housing policies are not satisfactorily inclusive of the need for green infrastructure to strengthen the sustainability and liveability of towns and cities. It is essential to ensure that households are living in homes that minimise energy costs, and are cost-effective to construct and maintain over the building's "life-cycle" (Arman, *et al.,* 2009:3038). Therefore, the need for strategies to aid construction of affordable buildings to enhance sustainability cannot be overemphasized.

An increase in demand which outweighs the supply of housing have led developers to less economical solutions in the provision of housing, the majority of which contribute to ill-health and disaffection, undermine community, and create excessive financial liability to the user. This situation must be changed due the greater influence of the built environment on the physical, economic, health and well-being of the people. It is against this backdrop that the research background is developed to answer the main research question and sub-questions formulated in this study.

1.4 RESEARCH QUESTIONS

Authors such as Bryman (2012:10), and Fellows and Liu (2008:56) have stated that the research questions are crucial towards precise and vigorous achievement of the research goal. Thus, research questions for this study were generated to probe the need for the research towards what is achievable within the research framework. The main research question is:

> *How could sustainability be introduced in the construction of affordable housing through the knowledge of housing financing, socio-economic aspects of sustainability and construction methods to enhance sustainability in housing delivery in South Africa?*

To appropriately address the issues surrounding the main research question, answers will be sought to the sub-questions set as follows:

i. How could problems relating to inclusion of sustainability in construction of affordable housing be mitigated?
ii. What are the cost mechanisms at the design stage that can be used to achieve construction of affordable housing to enhance sustainability?
iii. What are the cost factors that can be considered in achieving sustainable construction?
iv. What are the construction methods that could be implemented to enhance the construction processes to achieve sustainability in affordable housing construction?

v. How could efficient strategies that enhance sustainability be modeled to achieve construction of affordable housing?

1.5 AIM AND OBJECTIVES OF THE RESEARCH

The aim of the research is to establish a sustainable operational model that could be integrated into the housing construction process with a view to develop strategies to enhance sustainability in construction of affordable housing.

The specific objectives of the research are as follows:

i. Identify and ascertain user requirements in sustainable affordable housing.
ii. Identify and establish the effective housing finance mechanism to achieve construction of affordable housing and enhance sustainability.
iii. Evaluate and identify the key factors that affect the construction cost of sustainable affordable housing.
iv. Identify and establish construction concepts that could be used to produce affordable housing that is sustainable.
v. Develop and validate an operational model for implementing affordable housing construction to enhance sustainability.

1.6 SIGNIFICANCE OF THE RESEARCH

Application of sustainability concepts in the construction industry is gaining momentum, though not fully embraced in the delivery of construction products; this is evident by the dearth of relevant literatures in the subject area. However, a few studies have been conducted on the application of sustainability on environments as it influences building and building construction processes. Hill and Bowen (1997:238) proposed a framework for sustainable construction, which suggests environmental factors to be included in the specifications and other contract documents. Nair (2006:212) studied housing problems in Kerala, India and relate housing construction in the study area to social-cultural and economic impacts as well as the environment. The study developed a framework for developing affordable housing for the poor using alternative building materials. Akadiri (2011:11) studied the criteria for selection of building materials in the UK construction industry. The study developed "an assessment criteria for selection of sustainable building materials" for the construction industry. Wallbaum *et al.*, (2012:363) researched construction technologies that support the production of sustainable construction materials, suggesting technologies that relate to the use of local materials as the most sustainable solution for affordable housing projects. Mullinear *et al.,* (2013:278) conducted a study in Liverpool to establish a multiple criteria decision making method (MCDM) incorporating housing quantity and location to assess affordability instead of using housing capital cost and end-user income. Research conducted by Li, Yan, Liu, Lai and Uthes (2014:102) in China analysed the requirements that should be considered when planning and constructing green buildings. In all these studies, the concept of sustainability in construction has only been researched considering the areas of building materials and the environment, while few studies considered the social cultural well-being of the people and the environment on construction activities.

Consequent upon the aforementioned, many developers are reluctant to adopt sustainability in housing projects due to limited understanding and the pursuit of cost reductions in developing countries such as South Africa, which could be attributed to non-inclusion of cost parameters in sustainability evaluation assessment tools as noted in (Ding, 2008:456). It is therefore imperative to study the scenario towards enhancing sustainability in construction of affordable housing during the production process, to create a holistic strategy for developers and government in construction of affordable housing towards enhancing its sustainability. This strategy will boost the management of housing construction from inception through to completion and operational use of the building and in doing so, eliminate the fear of developers in adopting the concept of sustainability in construction of housing.

This study therefore contributes significantly to current discourse on sustainability in construction, to bridge the gap in previous researches and launch a novel approach of providing sustainable affordable housing, of which the demand currently exceeds its supply. In addition, this study developed a robust ‘housing construction sustainability enhancement model’ that combines sustainable construction criteria into a composite structural model for implementing construction of affordable housing towards enhancing its sustainability. This model will facilitate the decision-making process for housing developers and government agencies in construction of affordable housing to enhance housing sustainability and economic well-being of the citizen.

1.7 SCOPE OF THE STUDY

The focus of this study is to explore issues relating to the construction of affordable housing through knowledge of sustainability concepts, to enhance sustainability in housing delivery in the South African context. Thus, the construction organisations operating in South Africa and the agent of the South African government responsible for provision of affordable housing form the unit of analysis.

The study focuses on construction organisation across all provinces in RSA to ensure findings that reflects general trends across the country. The study further focuses on the construction organisation, the Department of Human Settlements (DHS), being the agent of government that is responsible for provision of affordable housing in the three largest provinces: Gauteng, KwaZulu Natal and the Western Cape. The study is limited to: general building contractors on grade 3 to 9 of the Construction Industry Development Board (cidb) registered list of contractors and the Deputy Director Generals (DDG) and Chief Directors (CD) for Housing Strategy, Housing Planning, Housing Stakeholder Relation, Housing Operational policy framework, Housing Governance framework, and Housing Advisory services in all nine provinces. The construction organisation and staff of DHS mentioned above were selected on the basis that they have the requisite experience in provision and construction of affordable housing.

1.8 OVERVIEW OF RESEARCH METHODOLOGY

The methodology for this study is largely quantitative and qualitative, which implies that the research process is largely deductive and inductive (phenomenological). Within these general frameworks, elements of mixed method research are incorporated to provide alternative insight into the phenomenon of affordable sustainable housing construction from a practitioner's perspective. Starting with basic observations and theoretical insights derived from literature, conceptual framework and research questions were developed, which was tested as the research progressed.

The data sourced is empirical in nature, and was collected using a mixed method approach whereby survey and case study were used concurrently. The advantages of mixed method research rest on the development of a research strategy that is effective in exploiting the advantages of quantitative and qualitative methods, while neutralising the "costs" or "risks" associated with each method (Grafton, Lillis & Mahama, 2011:11). Nonetheless, it is important to know how to acquire and interpret the data required for resolving the overall research problem. To address this, Leedy and Ormrod (2005:104) posited four fundamental questions for a researcher to answer which, if answered correctly, will bring the research into focus.

This study required both qualitative and quantitative data on factors considered when planning for construction of affordable housing. Data collected through the quantitative approach were analysed using Statistical Package for the Social Sciences (SPSS). The data was cleaned, coded and inputted into the SPSS worksheet and then analysed using descriptive statistics and Factor Analysis. The qualitative phase of the research took to the industry, the results generated through quantitative analysis for validation. However, information gathered at this phase was interpreted using thematic analysis, which is a research strategy to generate grounded theory from the qualitative data. Thematic analysis to Braun and Clarke (2006:82) is a research approach through which unanticipated insight into the research is generated. The unanticipated insight aims at generating theory to explain what is central in the data. Thereafter, the validated results of the analysis was inputted into SmartPLS software for model development.

To have access to the respondents (locating the data), the Sequential Mixed Methods technique was adopted, since the availability of people who have some specialised knowledge of the study background and are willing to make information at their disposal available are imperative in research (Teddlie & Tashakkori, 2009; Hesse-Biber & Leavy, 2011:46). However, more details on methodology and method are provided under the methodology and design chapter of this thesis.

1.9 ETHICAL CONSIDERATIONS

This study was carried out in accordance to Cape Peninsula University of Technology (CPUT) post graduate guidelines relative to research and other policies of the University relevant to the study. Further to this, the provisions of Section 2, Sub-section 12(2C) (Bills of Right) of the Republic of South Africa Constitution are adhered to in this research. In addition, other ethical issues highlighted by Leedy and Ormrod (2005:101); Mitchell and Jolley (2010:52) has guided the researcher throughout the study.

1.10 THESIS OUTLINE

The structure of the thesis is represented in Figure 1.1, and specific chapter descriptions are as follows:

Chapter One: This chapter provides background information for this research. It explains why the research is undertaken and the significance of the research to the construction industry. This chapter highlights the research aim and objectives, research questions and brief overview of the research methodology.

Chapter Two: Chapter Two builds theoretical underpinning for the research by reviewing literatures on housing legislations in South Africa. It provides information and arguments on the importance of incorporating sustainability principles in housing construction and the significance of engaging stakeholder participation in the housing construction process. In addition to focus on legislation, sustainable development and social sustainability related issues, this chapter also concentrates on housing affordability concepts, housing financing strategy and factors affecting cost of housing construction.

Chapter Three: Sequel to the review of literature in Chapter Two, this chapter presents the theoretical and conceptual framework upon which the research is predicated.

Chapter Four: This chapter provides an outline of the research methodology adopted.

Chapter Five: The chapter provides arguments for and justifies the choice of research approach and specific methods applied to collect data.

Chapter Six: Chapter Six present the results of quantitative data analysis and discussion of findings regarding sustainable construction practices and housing affordability as shown in Figure 2. The chapter discusses exhaustively the results of the quantitative research.

Chapter Seven: Presents the analysis of qualitative data.

Chapter Eight: This chapter was devoted exclusively to the development of the affordable housing sustainability enhancement model. The criteria to be incorporated in the model were examined, and the validation process and validation procedure will be presented in this chapter.

Chapter Nine: Chapter Nine highlights the summary, conclusion and recommendations to the application of the conceptual model in the industry.

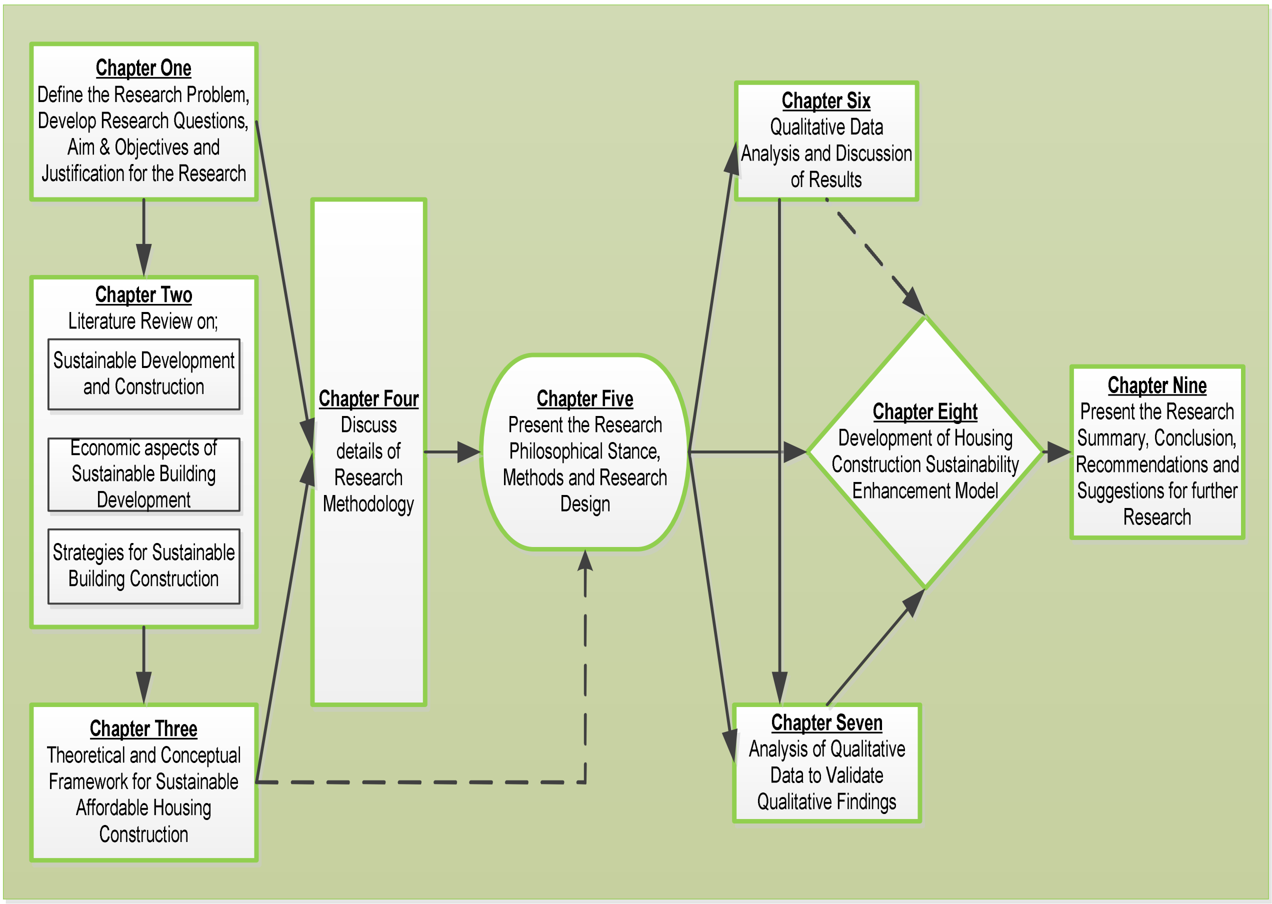

Figure 1-1: Thesis Organisation Outline

CHAPTER TWO
LITERATURE REVIEW

2.0 INTRODUCTION

Developing a strategy to enhance sustainability in affordable housing construction requires the development of both an economic and a social system that facilitates equitable access and opportunities to economically productive dwellings that enable sustainable livelihoods. The activities of the construction industry is key in creating good fortune for all, not just economic gains for a few without infringing on basic human rights. This chapter reviews literature on sustainable development and construction, economic aspects of sustainable affordable housing development and strategies for sustainable building construction, to provide theoretical underpinning for this study. This review thus provides an understanding of the factors influencing sustainable affordable housing construction and the long-term economic benefits of sustainable construction concepts to enhance sustainability in affordable housing construction.

2.1 SUSTAINABLE DEVELOPMENT AND CONSTRUCTION

2.1.1 SUSTAINABLE DEVELOPMENT

Sustainable development was initially conceived as a term most relevant to macro-economic development. It is only more recently that it has been applied to a consideration of the quality of development in human settlements and, by implication, housing (Choguill, 1999:133). Given the world record with respect to urbanization and the enormous expansion of residential areas, it is in this very sector where the greatest natural resource use occurs and from where the most waste products are generated (Choguill, 2007:144). Diesendorf (2000:34) describes sustainability as the goal of 'sustainable development' or 'economically sustainable and socially just development' which enrich the natural environment and human well-being. du Plessis (2002:5) defines sustainability as the condition or state that would allow continued existence of human beings. Gibberd (2005:1606) views sustainability as a complex interaction between 'environment, society and economy', and further stressed that these characteristics (environment, society and economy) are generally accepted as the important contributors to sustainability.

The sustainability concept became a major issue of concern due to recognition of an impending and assured global disaster on the depletion of the world's resources (Vallero

& Braisier 2008:174). In addition to all of these, sustainability definitions can be summarized with the definition given by ISO (2008) as "*the state in which components of the ecosystem and their functions are maintained for the present and future generations*". What is, however, common in all is ensuring a better quality of life for everyone, now and for future generations.

Pearce (2005:481) argued that the 'triple bottom line' sustainability concept is an impression that a sustainable development can have financial gain, cause no damage to the environment and contribute to community development. The author further stated that every developmental project damages the environment, and few developments create social-coherence. Pearce (2005:481) posited the need to identify the intersections between the goals of sustainable development, and to develop a mechanism for evaluating the intersections. In the same vein, Halliday (2008:7) stressed that establishing the links between the goals of sustainability will ensure the formulation of long term solutions to a basic developmental problem that is backed with strong political-will.

Generally, the concept is based on the interaction between the 'triple legged concept' that surrounds human existence, shown in Figure 2.1. The product of interaction between 'social and environment' is a bearable development, 'social and economic' produce an equitable development, while 'economic and environment' leads to viable development.

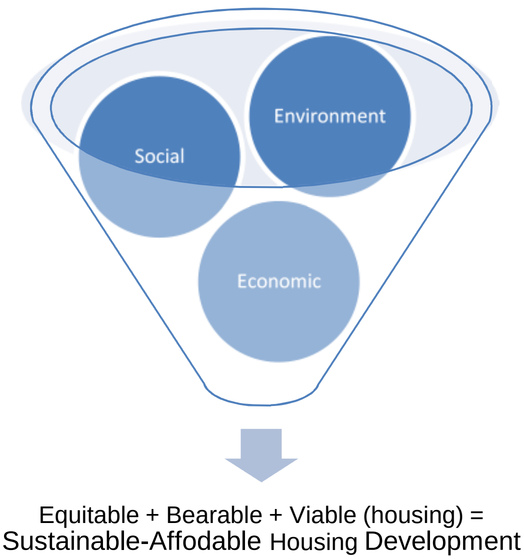

Figure 2. 1 Product of interactions between the tripod stand of Sustainability

The WCED Report (1987:43) gave rise to the well accepted definition of 'Sustainable Development' which is stated in the previous chapter. It is therefore necessary to critically look beyond the definition and probe into making a sustainable building affordable to the rural population, as it has been recognised in WCED Report (1987:16) which states, "*Poverty is not only an evil in itself, but sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfill their aspirations for a better life. A world in which poverty is endemic will always be prone to ecological and other catastrophes"*.

Sustainable development according to Vliet (1996:350-351) is poised to firstly propose a framework for "*meeting the needs of the present*", in terms of:

Economic needs: These include access to adequate livelihood or productive assets from which this can be gained; also minimum income or economic security when unemployed, ill, disabled or otherwise unable to secure livelihood.

Social, cultural and health needs: These include a shelter which is healthy, safe, affordable and secure, within a healthy neighbourhood environment with provision for piped water, sanitation, drainage, transport, health care, education and child development, as well as a home, workplace and living environment protected from environmental hazards, including chemical pollution. Also important are needs related to people's choice and control, including neighbourhoods which they value and where their social and cultural needs and priorities are met. Shelters and services must meet specific needs of children, adolescents and adults. Achieving this implies a more equitable distribution of income between nations and within nations.

Environmental needs: These include freedom in decisions regarding management and development of one's own home and neighbourhood, within a broader framework which ensures respect for implementation of environmental legislation.

Secondly, "*without compromising the ability of future generations to meet their own needs", by:*

Minimising use of non-renewable resources: This includes minimising consumption of natural resources and minimising waste of scarce mineral resources. There are also cultural, historical and natural assets within cities which are irreplaceable and thus non-renewable, such as, historic districts and parks and natural landscapes which provide city inhabitants with space for play, recreation and access to nature.

Sustainable use of renewable resources: This includes cities drawing on freshwater resources at levels which can be sustained; keeping to a sustainable ecological footprint in terms of land-area from which producers and consumers in any city draw agricultural crops and wood products.

Summarily, sustainable development is a process which aims to provide a physical, social and psychological environment in which the behaviour of human beings is harmoniously adjusted to address the integration with and dependences upon nature in order to improve and not to impact adversely on the present or future generations.

2.1.2 THEORETICAL BACKGROUND OF SUSTAINABLE CONSTRUCTION

Sustainable development is the foundational principle towards ensuring a decent quality of life for future generations. The United Nations (UN), in recognition of this fact and the impending and assured global disaster, commissioned WCED to conduct a study of the world's resources. The WCED in the 1987 report entitled "*Our Common Future*" introduced the term 'Sustainable Development' and defined it as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987:43).

Sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfil their aspirations for a better life (WCED, 1987:16). Moreover, sustainable construction covers a broad interaction between construction stakeholders and the entire construction process. The construction industry comprises civil engineering and building construction, and their activities poses extensive impacts on the environments (Hill & Bowen, 1997:225; Ding, 2008:451). It is essential to note that construction implies all activities from client briefing, site-activities to creation of buildings. It is on this premise that the International Council for Research and Innovation in Building and Construction (CIB) defined sustainable construction as construction which is set to reach the goal of sustainable development (CIB, 1999), the CIB Agenda 21 further explained that sustainable construction is achievable through;

- Management and organisation of construction processes
- Material selection and construction methods
- Resources consumption

Hill and Bowen (1997:225) describe sustainable construction as the concern of the construction industry to attain sustainability in creating a healthy built environment using resources efficiently under ecologically based principles. Raynsford (2000:16) further describes sustainable construction as set of processes by which a profitable and competitive industry delivers built assets (buildings, structures, supporting infrastructures and their immediate surroundings) which;

- Enhance quality of life and offer customer satisfaction
- Offer flexibility and the potential to accommodate future changes in user requirements
- Provide and support enviable natural and social environments
- Maximise the efficient use of resources

However, Raynsford's definition did not only give emphasis to the product, but included the process as well. It introduces some aspects of social sustainability and support for enviable social environment, while some aspects of environment and economic sustainability introduce maximising the efficient use of resources and emphasising profitability and comprehensiveness of the industry. Constructing Excellence (2004) introduces sustainable construction as the application of sustainable development in the construction industry, which is aimed at ensuring a better quality of life for everyone now and for future generations through:

- Social progress which recognises the needs of everyone
- High and stable levels of economic growth and employment whilst
- Protecting and if possible enhancing the environment
- Using natural resources prudently

According to Kaatz, Root, Bowen and Hill (2006:310), the ultimate goal of sustainable construction is a practice towards the creation of a sustainable built environment and sustainable settlements. Thus, Kaatz, *et al.,* (2006:310) assert that the key objective of sustainable human settlements is to facilitate the developing of:

> "*societies that will make efficient use of resources within the carrying capacity of ecosystems and take into account the precautionary principle approach by providing all people with equal opportunities for a healthy, safe and productive life in harmony with nature and their cultural heritage and spiritual and cultural values, and which ensures economic and social development and environmental protection"*.

2.1.2.1 Awareness and Adoption of Sustainability in Construction Industry

Previous studies showed that the level of awareness regarding sustainable construction issues has been found low in several countries. A survey conducted in the Netherlands in 1998 showed that a quarter of architects and half of the building contractors did not know what sustainable construction was (Van Bueren, 2002:81). Furthermore, Watuka and Aligula (2002), in their study of sustainable construction practices in the Kenyan construction industry, reported that sixty four percent of the respondents on a questionnaire administered to architects, engineers, quantity surveyors and contractors indicated lack of awareness about sustainable construction practices. Similarly, du Plessis (2002:17) noted that the sustainability concept is new in the construction sector, as the concept is yet to be an integral part of decision-making and business practice in the construction industry. Subsequent to low level of awareness, UK governments declared promoting awareness and understanding of sustainable construction as one of the objectives of the UK strategy for more sustainable construction (DETR, 2000).

Lack of awareness might be attributed to a number of factors, such as lack of clear conceptualization of sustainability, lack of clear case for sustainability benefits, and lack of integration of sustainability issues in education and training programmes. Other contributing factors may include the traditional perception that limits the understanding of sustainability within the environmental dimension, the dominance of economic drivers in the performance of businesses at the expense of social and economic issues, and lack of long-term perspective.

Awareness of green construction is closely related to the public awareness of environmental issues. Without raising the level of awareness in relation to sustainable construction issues, progress in construction practice would not be possible to achieve. However, raising awareness in itself is not sufficient; appropriate action has to follow to achieve the desired outcome of providing sustainable housing.

2.1.2.2 Barriers to adoption of sustainable development concepts

It has been largely recognized that environmental issues are crucial in the construction industry as the industry activities depend on the environment for its resources. Lack of awareness is not the only barrier to achieving sustainability. Meryman and Silman (2004) identified three primary barriers in sustainable construction; they identified the economic factor as the most critical barrier, and included policy and technical issues. Halliday (2008:50) viewed stringent planning and building control provisions as potential barriers to implementation of sustainable development concept. The author cited regulations against the use of rainwater pipe, use of new materials such as unfired earth (which is gaining increased acceptance), solar-oriented layouts, density of dwellings and alternative traffic arrangements. Ding (2008:463), in the study conducted in Australia, opined that the lack of a sustainability index developed using multiple criteria of ecological, social and economic growth in the society have posed serious challenges to sustainable design solutions and building operations.

Study by Qi, *et al.,* (2010) showed that managerial concern was the most important driver for the adoption of green practices by contractors. According to the research, the main barriers of sustainable construction were classified into four (4) fundamental aspects, i.e. economics, technology, awareness and management. In addition to these, barriers, such as the industry's fragmented nature, lack of long term perspective, clients' unwillingness to share burden, lack of clear knowledge on the concept of sustainable construction and its benefits, regulatory constraints and inconsistent government policy, and lack of fiscal incentives, also hinder progress in adoption of sustainable construction (Adetunji, Price, Fleming & Kemp, 2003:187). The unwillingness of industry practitioners to change the conventional way of specifying existing methods and processes constitutes a technical barrier to the adoption of a sustainable construction concept (Chen & Chambers, 1999; Meryman & Silman, 2004). Adoption of a sustainable development concept holistically lies in the purview of national government. Government must enact policies against unsustainable practices and penalize failure at all levels. Construction industry professionals must also develop policies to enable its activities to respond to threats and reverse unsustainable trends. However, all of these barriers identified from previous studies and the many more that will be further identified will be investigated, to evaluate their impact towards adoption of sustainable construction within the South African context.

2.1.3 SOUTH AFRICAN CONSTRUCTION INDUSTRY

The built environment is the reflection of a nation’s developmental progress as well as the physical foundation for economic and social advancement into the future. Construction occupies a strategic position in the economic growth of both the developed and developing nations. Globally, the construction industry accounts for about ten percent of the world economy (Construction Industry Development Board (cidb) 2004:7). Although, approximately seventy percent of construction investment is accounted for in the USA, Western Europe and Japan, while the African continent accounts for about one percent. However, the Confederation of International Contractors’ Association: CICA (2012) expresses that although the contribution of construction to GDP might appear small, its effects on the world economy is enormous considering the investment in infrastructure, energy efficiency, housing which are fundamental to economic growth as well as job creation. Figure 2.2 shows the contributions of construction in both developed and developing nations to world GDP. It is worthy of noting that the South African construction industry has the highest contribution to world GDP in the African continent, it contributes around US$287.2 billion. The status of the construction industry is measured within the context of society's development and challenges. These challenges include the developmental objectives of the regulating agencies, socio-economic trends and policies that affect the industry.

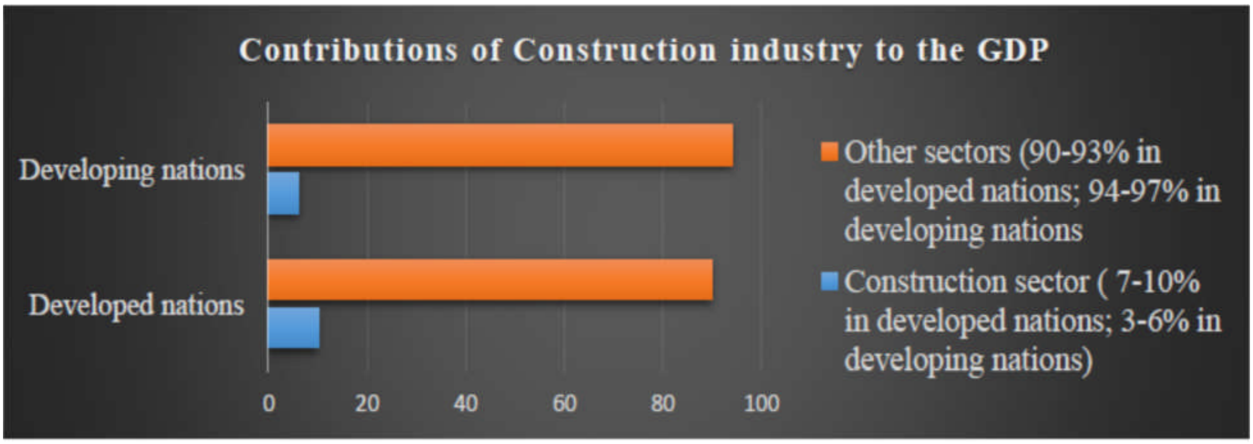

Figure 2. 2: Construction Industry Contribution to World GDP (Adapted from Lowe, 2003)

The South African construction industry is regarded as a national asset that has to be developed and transformed to meet both the local and global challenges, since it is saddled with the responsibility to implement government commitment to infrastructure development to achieve economic growth (cidb, 2004:9). The construction industry sector in South Africa has been described as an important factor in the economic growth of the nation (Dlungwana, Nxumalo, Van Huysteen & Noyana, 2002:3). This is evident in the appreciable success and growth experienced by the sector in recent times, such as the increase in its total income from ZAR100.4 million in 2004 to ZARR268.1 Million in 2011 (StatSA, 2011). Continuous spending on infrastructure by government also enhances the status of the industry and its contributions to national development. However, the prevailing industrial, economic and socio-cultural environments in South Africa presents quite a number of opportunities and threats to the sector. Within construction, the opportunities include the patronage by the public sector and the increase in government spending in the provision of infrastructure. Other opportunities include the presence of an enabling business environment and lack of stringent entry barriers to construction organisations (cidb, 2012).

However, despite the attractive outlook of the industry, it is confronted with a number of threats which have significant effects on its performance. The industry has over thirty laws that have a direct impact on its development (cidb, 2004:8). Some of these laws, for example, include: the Preferential Procurement Policy Framework Act 2000, that provides for creation of categories of preference in the award of contracts, to enhance the development of organisations owned and managed by Historically Disadvantaged

Individuals (HDI) in South Africa; the Broad-Based Black Economic Empowerment Act 2004 creates a legislative framework for promoting economic empowerment to black South Africans and provides a code of practice related to procurement criteria and guidelines. These laws affect the industry capabilities, performance and competitiveness; in fact, it has negative effects on Foreign Direct Investment (FDI), which represents the main source of development capital for emerging markets in the current world economy. Other threats include a lack of a competitive environment, corruption and economic instability (Tobin & Magenuka, 2006:3; Bowen, Pearl & Akintoye, 2007:204). These threats and many other factors identified in the literature have resulted in a decrease in the industry contribution to the GDP over the years, as is shown in Figure 2.3. Construction industry contribution to GDP was 5% in 2006 and it decreased continuously to about 2.7% in 2012.

Figure 2. 3: Contribution of South African Construction Industry to GDP

2.1.4 HOUSING SITUATION; ISSUES AND CONCERNS

Human settlement problems vary from individual to individual, rural to urban, and from country to country in terms of both quantity and quality. The unmet demand for housing, alongside poverty, has led to the emergence of slums in many African and developing countries (Un-Habitat, 2012:7). This is evident in Sub-Saharan Africa where the majority of the housing activities are being done by acquiring land through purchase or invasion. In such cases, poor people with limited income and expertise construct their own houses with available resources, and gradually improve the structure in due course of time. The attendant consequence of this is that, the quality of the houses built is miserable, with insufficient basic services, unhygienic surroundings, lack of access to safe water and proper sanitation (Govender, Barnes, & Pieper, 2011:341; UN-Habitat, 2012:5).

The housing problem of developing countries differs greatly from that experienced in developed economies, and rural and urban housing also exhibit their own peculiar characteristics. There are a number of constraints that slow down the housing development programmes and the development of a sustainable habitat. Lack of effective implementation strategies, inadequate supply of affordable land and infrastructure, and inadequacy of housing finance systems are a few among such constraints.

Access to affordable building materials is one of the major limitations of the poor in developing countries to provide adequate housing. Out of the capital cost of building construction, more than fifty percent is incurred on building materials in developing countries. The gap between the rising demand and the stagnating, and in many cases declining, production levels is widening at an alarming rate, leading to the escalation of prices of building materials in many developing countries, seriously affecting the affordability of housing for the vast majority of the population (UNCHS, 1990).

2.1.5 SOUTH AFRICA HOUSING LEGISLATION AND SUSTAINABLE DEVELOPMENT POLICY

This section provides an overview of housing policy development since 1994 as well as the sustainable development policy of the South African government. It briefly discusses the “White Paper on Housing 1994” and “Breaking New Ground” (BNG) policy on housing. In addition, it briefly explains South African Green Building Legislation.

2.1.5.1 Housing Legislation and Policies in South Africa

Section 26 of the constitution of the Republic of South Africa (1996) enshrines everyone’s right of access to adequate housing. Since the advent of Democracy in 1994, a series of legislation and policies have been put in place to give effect to this right. Despite this, the inability of the South African government to deliver houses to its citizens is still evident, the situation which Tissington (2011:8) describes as fiscal constraint on the part of government. Prior to 1994, there were existing Acts, such as The Housing Act 35 of 1920, which was to control the Housing Department of the Local Authorities; the Urban Areas Act of 1923 that emphasised the establishment of three forms of accommodation; and the Group Areas Act of 1950 that provided for the enforcement of the policy of division in residential areas, among other Acts (UN-Habitat, 2012:7).

This section sets out to examine the basis on which the 1994 White Paper on Housing, and Breaking New Ground: 2004 Comprehensive Plan for Housing Delivery are established.

2.1.5.1.1 The 1994 White Paper on Housing

The 1994 White Paper on Housing is the principal and predominant national housing policy with the aim to "create viable, integrated settlements where households could access opportunities, infrastructure and services within which all South African will have access to:

- A permanent residential structure with secure tenure, ensuring privacy and providing adequate protection; and
- Portable water, adequate sanitary facilities including waste disposal and domestic electricity supply.

The goal of the 1994 White Paper on housing, as stated by NDoH (2007:9-11) and Tissington (2011:60) was established on seven key strategies:

- Stabilising the housing environment to ensure maximal benefit of state expenditure on housing and mobilising private sector investment
- Rationalising institutional capacities by defining the roles and relationships in the public sector
- Establishment of a housing subsidy programme
- Mobilising housing credit on a sustainable basis
- Supporting Peoples' Housing Process (PHP)
- Facilitating the speedy release and servicing of land
- Coordinating and integrating government investment in development by maximising the effect of State investment on a multifunctional basis

While identifying the constraints towards resolving the South African housing crisis, the White Paper on Housing (1994:15-16) highlighted nine main constraints of which "housing construction sector" makes the list. The policy outlines construction sector constraint as:

- Inadequate development framework: access to land, poor access to bulk infrastructure networks and lengthy planning procedures hamper developers' ability to undertake housing development expeditiously
- Limited capacity: the construction sector and building materials supply need to be in significant capacity to enable it to deliver the number of houses required

- Potential bottlenecks: significant potential bottlenecks exist in certain subsectors of the construction and building materials supply industries
- Incompatibility of demand and supply: geographic distribution of demand does not match present location of construction capacity and building materials suppliers

Based on the above strategies and the constraints of the construction sector in delivering housing, it would have been expected that equal priorities and a level playing ground will be accorded to all the delivery options, in order to have a rapid and efficient housing sector. However, the policy identifies participation of emerging contractors as a way to increase the capacity of the construction sector. The situation is, however, different due to the neglect in empowering the poor to provide labour input to the construction sector, thereby slowing the rate at which the various delivery options have been providing houses and creating a huge gap between demand and supply.

2.1.5.1.2 People's Housing Process (PHP)

People's Housing Process (PHP) was developed by the South African government as a parallel process of housing delivery to the "White Paper on Housing". PHP is a process through which the beneficiaries are involved in the construction process, in order to make savings in cost of construction. The idea of community participation had been part of the White Paper on Housing, reflected in the requirement for social interaction between developers and communities.

The PHP was developed partly to encourage greater beneficiary participation and partly due to pressure from international organisations such as the United Nations (UN), which had showed beneficiary participation results into more responsive and effective low-cost housing delivery. The policy objective of the PHP is to work with NGOs in the housing sector to assist communities in planning and implementing the construction of their own housing settlements through using beneficiaries as the labour force to build houses, and offset the labour against the National Housing Subsidy Scheme (NHSS) savings requirement. The PHP, however, gave poor households the opportunity to overcome the affordability barrier and gain access to a house without the long wait to access housing finance.

According to Tissington (2011:63) PHP enjoyed wide spread support by a number of South African NGOs, who later called for change to PHP on the basis that:

- PHP shifts part of the cost of housing onto the poor

- Participation is limited to housing construction with little or no influence over location and layout around the existing patterns of land occupation
- Organised communities have not been able to manage infrastructure projects
- Through the PHP, the state is abrogating its responsibility and shifting the burden of delivery to the poor

2.1.5.1.3 Breaking New Ground (BNG): Comprehensive Plan for Housing Delivery, 2004

The Comprehensive Plan for Housing delivery, as indicated by SHF (2010:7) and Tissington (2011:66), was put in place to upscale housing in terms of the quality and location through a variety of housing programmes and projects. This approach was to change from the earlier supply-centred approach to a demand-centred approach, necessitated by the needs of the beneficiaries (SHF, 2010:7; Tissington, 2011:66). NDoH (2008:31) states that BNG is predicated on nine elements as highlighted below:

- Provision of support to the whole residential property market
- Shifting from just housing to sustainable human settlements
- Building on existing housing instruments
- Adjusting institutional arrangements within government
- Building institutions and capacity
- Defining financial arrangements such as widening funding flows
- Creating jobs and housing by building capacity
- Building information, communication and awareness by mobilising communities
- Establishing systems for monitoring and evaluation in order to enhance overall performance

BNG acknowledged the change in nature of the housing demand, the increasing average annual population growth, the drop in average household size, significant regional differences, increasing urbanisation, skewed growth of the residential property market, growth in unemployment and a growing housing backlog despite substantial delivery over the previous decade. BNG recognised that the lack of affordable, well-located land for low-cost housing have led to development on the periphery of urban areas, thereby achieving limited integration (Tissington, 2011:66). However, despite the progressive nature of BNG in offering a choice of housing options and a demand-driven approach, its stated intent to offer a greater choice of tenure, location or affordability has not been realised significantly (Tissington, 2011:67). In conclusion, good policies and legislation do not necessarily translate into action if the political will by the government officials that are to implement the policies and legislation is lacking.

2.1.6 SOUTH AFRICA SUSTAINABLE CONSTRUCTION POLICY

The built environment makes a significant contribution to environmental degradation. In RSA, operations of the building sector account for 23% of greenhouse gas emissions, while emissions from the manufacture of the major building materials amount to around 18mtCO_2 (around 4% of the total CO_2 emission) per year (Gunnell, 2009:3). However, the negative environmental impacts of building have led to the emergence of sustainable building concepts, which are designed to be energy and water efficient, use non-hazardous materials and provide healthy productive environments. Although, efforts to address the challenges of climate change through facilitating a viable and fair transition to a low-carbon economy are essential to ensure an environmentally sustainable economic development and growth path for South Africa. The government has taken steps to coordinate and develop a coherent policy framework to curb GHG emissions by 34% by 2020 and 42% by 2025, below the business-as-usual (BAU) trajectory, subject to the provision of adequate financial, technological and capacity-building support by developed countries (Department: National Treasury (DNT) 2013:7).

The government carbon emission programmes are aimed at enhancing South Africa's climate change mitigation and adaptation efforts in the energy, water, transport and waste sectors, and including the construction sector. Several fiscal support measures for addressing climate change are proposed to complement the set of priority programmes and support South Africa's GHG mitigation strategy. These measures include options to reform existing expenditure programmes and tax incentive measures. It sets the vision for managing the impacts of climate change effectively through adopting appropriate policy interventions to guide the transition to a climate-resilient, low-carbon economy. The efforts are targeted at mitigating the effects of climate change; adapting processes, systems and approaches; building technology and capacity; mobilising financial resources; and developing an appropriate system for monitoring and evaluation (DNT, 2013:9-10).

South Africa is making progress in ensuring that its economic development is sustainable, and particular attention is paid to the way in which economic, social and environmental assets are used. Several environmental problems have been identified and various government departments have developed policy measures to address these concerns, particularly in the areas of climate change, air quality, waste management, and surface and groundwater pollution. It is recognised that good-quality growth is essential to ensure that the country's development is sustainable and its environmental resources remain intact to meet the consumption needs of both present and future generations. These priorities are reflected in the National Framework for Sustainable Development in South Africa (DEA, 2008), as well as the National Strategy for Sustainable Development and Action Plan (DEA, 2011b). This gradual approach will send the necessary policy and price signals to investors and consumers of the need to ensure that future investments are more climate resilient. This will minimise the need for retrofitting, as well as minimise the risk of embarking on redundant, large-scale, major capital projects and investments. It is proposed that the carbon tax be introduced as part of a package of interventions to ensure that the primary objective of greenhouse gas (GHG) mitigation is achieved, and to minimise potential adverse impacts on low-income households and industry competitiveness (DNT, 2013:7).

2.1.7 THE CHALLENGES OF SUSTAINABLE CONSTRUCTION

Sustainable development poses many challenges to both developed and developing countries (du Plessis, 2002:17). Although previous researches have shown that the developed world have made frantic efforts to address the challenges of sustainable construction, developing countries are still lagging behind in addressing these challenges (du Plessis, 2002:17). du Plessis (2002:17) identifies nine challenges facing sustainable construction in both the developed and developing countries as; internalising sustainability, reduction in profit, resource mobilisation, public awareness, improving quality of the construction process and its products, reducing resources use (reduction of building materials wastage, increasing the use of recycled waste as building materials, energy efficiency in buildings, water conservation, durability and maintenance), innovation in building materials and methods, environmental health and safety and procurement procedures.

2.1.8 Summary

In this section, sustainable construction and development was brought into focus within the realm of affordable housing construction for the low-income population. There is no doubt that the activities of the construction industry contribute greatly to the depletion of natural resources in an attempt to meet its obligations in provision of sustainable buildings that are bearable, equitable and economically viable to the occupants. The goal of sustainable development is to provide a physical, social and psychological environment in which the behaviour of the people is harmoniously adjusted to improve the present and provide for the future. The discussions in this section have shown that awareness of sustainable construction is low in many countries, situations that some authors attributed to lack of training and education on sustainable building design, lack of clear conceptualization of sustainability, lack of clear case for sustainability benefits, and lack of long-term perspective on sustainability. The barriers to adoption of sustainability in construction were highlighted, some of which include; economic implication of construction, policy issue, technology, lack of clear assessment tool to evaluate building design, and unwillingness of the construction industry practitioner.

The South African construction industry is faced with a number of threats, which significantly affect its performance in sustainable housing construction. The unmet demand, due to incapacitation of the construction industry in provision of housing, is evident in the sporadic emergence of slump/shacks in both urban and rural communities in developing countries. In order to avert continual emergence of shack building, the South African government has legislated a series of housing policies over the years, many of which were adjudged to have influenced delivery of affordable housing significantly, though the houses built lack the tenet of sustainable development.

2.2 ECONOMIC ASPECTS OF SUSTAINABLE BUILDING DEVELOPMENT

2.2.1 AFFORDABLE HOUSING CONCEPTS

According to Miles, *et al.,* (2000) and Wallbaum, et al. (2012:354), affordable housing is a dwelling where the total housing costs are affordable to those living in the housing unit. Conversely, an affordable house is described as a house that a family group can acquire within a given period, which generally ranges from 15 to 30 years. This period is directly connected to the acquisition capacity of the group and the financial support that they can obtain in terms of loans, credits and subsidies (UN Habitat, 2009). While to Assaf *et al*., (2010:291), affordable housing is a physically adequate housing that is made available to those who, without some special intervention by government or special arrangement by the providers of housing, could not afford the rent or mortgage payments for such housing. 'Special intervention' means arrangements that are not ordinarily made in the conventional marketplace. These arrangements may involve creative financing, waivers of land use or building regulatory requirements to reduce costs, construction of smaller 'starter' homes or financial assistance from public sources (Assaf, *et al*., 2010:291). Consequent upon the aforementioned, affordable housing is a type of housing that takes into consideration the well-being of the community for which the housing is provided and of which its construction requires some special efforts to bring adequate shelter within reach of low-income households.

Generally, housing can be considered affordable for a low or moderate income household if that household can acquire use of that housing unit (owned or rented) for an amount up to 30% of its household income (Miles, *et al*., 2000; Chatfield, *et al.,* 2000). When the monthly carrying costs of a home exceed 35% of household income, then the housing is considered unaffordable for that household. In general, there are two major factors that affect the provision of affordable housing: household income and housing cost. First, household income is a primary factor in housing affordability. The most common approach is to consider the percentage of income that a household is spending on housing costs. Affordable housing should fit the household needs, should be well located in relation to services, employment and transport, and the cost for housing should not be more than 30% of income. Second, the global increase of material prices and construction cost hinders government from embarking on new affordable housing projects.

There are number of ways through which investment potentials on housing projects are appraised, but many still bore down to the traditional and fixed ways of using payback as the yardstick. Traditional accounting systems generally rely on an initial capital sum to finance the project, which means that the projects needs the total cost as up-front capital. Financing sustainable housing projects could be hinged on the issue of bringing corporate social responsibility (CSR) into the financial accounting system. This is often referred to as the triple bottom line: environmental sustainability, social sustainability and financial sustainability. CSR caught on because businesses became aware of the need not to incur unexpected costs in the future through their unintended negative impacts on the wider society.

In developing countries, such as South Africa, the low-income groups are generally unable to access the housing market. Therefore, cost effective housing is a viable option. The concept has more to do with budgeting and seeks to reduce construction cost through better management, appropriate use of local materials, skills and technology but without sacrificing the performance and structure life (Tiwari *et al.*, 1999 cited in Tam, 2011:156).

2.2.2 AFFORDABLE HOUSING CONSTRUCTION PROCESS

Provision of sustainable affordable housing has linkages with several social issues that impact directly on the severity of housing shortfalls. Noble (2007:5), states that the process of affordable housing construction starts with identification of housing as a problem, which is generally derived from census taken prompted by citizen outcry or visual view of homelessness within a community.

An affordable housing process takes into account accessibility measures for intending occupants, adequacy and quality, availability measures and affordability measures. According to Susilawati and Armitage (2004), there are six categories that have to be satisfied when providers deliver affordable housing, namely: appropriateness of the dwelling, housing and social mix, tenure choice, location, quality of environmental planning, and design and cost.

A study by Abdellatif and Othman (2006) to improve the sustainability of low-income housing projects in the United Arab Emirates (UAE) reveal that government authorities initiated the briefing of the projects, and end-users were not involved in the briefing and in the design process. Hence, residents' requirements were not captured and their needs were not reflected in the building design. Although, Reffat (2006) opines that participation of end-users in the housing development should be the right of every stakeholder who will be affected with the final product.

2.2.2.1 Cost of affordable housing construction

Housing costs are the single largest expenditure, as many households and families are spending so much on housing that they cannot meet other expenses. Households in the low-income range have great difficulty finding adequate housing that can accommodate their needs within their financial means. Such poor people can reduce the quality and quantity of their food, but building codes and occupancy standards can preclude reductions in housing consumption. At some point, the choice becomes to pay up or be homeless.

A number of factors contribute to the high cost of affordable housing, some of which include demographic changes and trends, the volume and composition of immigration from within and abroad, the available supply of rental units, the availability of land for housing in communities, costs of building, land costs and the supply of labour and trades.

Lowering the cost of construction can be one of the effective strategic measures in the development of a strategy for affordable housing. This requires determining and considering the most cost influential factors when making decisions on lowering construction cost. It is pertinent to identify factors that influence cost of constructing affordable housing. However, Assaf *et al*., (2010:307) in their study reveal ten factors affecting cost of construction of affordable housing. These are: inadequate labour availability; lack of coordination; material standard; duration of contract period; design quality; cost of material; design change; disputes on site; poor financial control on site; and previous experience.

Furthermore, achieving an affordable sustainable building requires a cost saving strategy which must be incorporated into the project's conceptual design phase. Kubba (2012:501) suggested holistic analysis of direct capital and direct operating costs. Direct operating costs include all applicable expenditures required to operate and maintain a building over its life span. These costs include: total cost of energy use (e.g. heating and cooling), water use, insurance, maintenance (such as painting, roof repairs and replacement), waste management and property taxes (Kubba, 2012:503).

Most sustainable construction solutions in buildings are constrained by excessive costs or by very limited choice possibilities for quality and, at the same time, low cost construction solutions (Coimbra & Almeida, 2013:10). However, a deeper understanding of the costs and techniques used in the operation of energy-efficient systems and their impact on social and economic savings of economic resources in families who live in housing over the life of the building is essential.

2.2.2.2 Economic benefits of sustainable construction

An affordable house is a long-term investment that should provide benefit to its owners in terms of comfort, quality and lifespan (Jenkins *et al.,* 2007). According to du Plessis (2002:17), an economically efficient construction industry enhances environmental sustainability by ensuring least-cost methods of construction that encourages optimal allocation of resources, and discourages waste. Economic sustainability within construction requires that social and environmental costs are adopted and reflected in the final product prices (du Plessis 2002:17). However, the cost savings on energy consumption and other services charges over time are believed to offset part of the increased capital cost (Chang, Rivera & Wanielista, 2011:1182).

Succinctly, there is growing awareness of the social equity argument in favour of making sustainable housing solutions more widely available (Sulivan & Ward, 2012:314). Doing so grants access to the health benefits of sustainable upgrades (such as indoor-air quality), as well as the economic benefits of energy and water saving technologies.

Sulivan and Ward (2012:314) further express that lack of energy efficient housing in low-income communities means that poorer households were subjected to incurring higher utilities costs relative to their incomes and capacity to pay.

Previous researchers have attested that sustainable construction provides an opportunity to use resources more efficiently while constructing a building that enhances human health, creates a better environment and saves cost (Kubba, 2012:493). A study conducted in the UK by McGraw-Hill Construction in 2006 reported in Kubba (2012:494) reveals that occupancy rate for sustainable buildings was 3.5% higher, rent level was 3% higher and operating cost of sustainable building was estimated to be 8% to 9% lower than the traditional building

2.2.2.3 Construction cost as barrier to sustainable building development.

Construction cost has been the most important consideration for the implementation of any construction project. It is worthy to note that cost plays a prominent role in decisions on implementation of sustainable construction (Kunzlik, 2003; Meryman & Silman, 2004; Ofori & Kien, 2004). The construction industry is making financial decisions that have wide social and environmental impacts with a viewpoint that building in a sustainable manner is unaffordable. The overriding assumption of practitioners in the construction sector is that sustainable construction practices will increase cost and reduce profit (du Plessis, 2002:17; Halliday, 2008:61). Halliday (2008:61) further argues that if sustainable building is cheaper to construct and more profitable, it would have been widely accepted by prospective building owners and developers. However, since they are often costly, sustainable applications are most easily adopted among the more economically advantaged sectors in the middle and upper-income residential neighbourhoods (Sulivan & Ward, 2012:314) or among “back to the city” gentrifies who can afford the costs of “smart housing” with higher levels of energy efficiency and investments in renewable energy applications.

Halliday (2008:61) asserts that sustainable innovations required cost implication of time, planning, risk and enhanced information requirements. Liu, Low, and He (2012:) opined “cost control” as the biggest challenge to implement sustainable construction practices in China. Authors like Shi, *et al.,* (2013:2); and Qaemi and Heravi (2014:456) believe that the utilization of sustainable techniques, such as high performance insulation protection, and water and energy saving equipment, often escalate construction capital cost. Halliday (2008:66) affirms that sustainable construction attracts additional cost in areas of building materials, such as high-performance paint, and extra design time. du Plessis (2002:17) suggests investment in technological changes required for the application of the sustainable concept.

While it is true that a change to more sustainable construction will incur costs, there are also associated savings resulting from efficient use of resources, higher productivity and reduced risk. Drainage constructions, which tend to increase cost in the past, are now a cost neutralizer due to construction of a 'sustainable urban drainage scheme'; this thus reduced cost of pipes and hard drainage (Halliday, 2008:66). Although, innovators will have their profit margins reduced in an attempt to enhance sustainability in building when put in direct competition with unsustainable practices. The challenge is to explore these benefits, to increase profitability as well as make sustainable construction affordable for all. Hence, the need to adopt a construction method that minimises the use of resources during construction of affordable housing.

2.2.3 CHALLENGES FACING AFFORDABLE HOUSING CONSTRUCTION

The affordable housing sector has been regarded as one of the less penetrated markets by private companies (World Bank, 2006). Though, the sector provides a wide range of opportunities for development, coupled with a series of challenges to be overcome. Several challenges to affordable housing have been put forth in the extant literature. Wallbaum, *et al*., (2012:353) highlight eight factors as key challenges to affordable housing construction: scarcity of resources; lack of sufficient funds; shortage due to urgency of demand; shortage of skilled labour; quality control; wastage due to inefficiency; lack of added value creation; and quality and location. Addressing these key challenges, Wallbaum *et al*., (2012:353) adopt a stepwise approach. The first step, screening of construction technologies used in affordable housing programmes; second, the development of an indicator based assessment system; and third, technology's assessment and ranking.

2.10.1: Scarcity of resources

The consumption of resources increases tremendously due to rapid urban growth and changing living standards in developing economies. In recent times, a decline in the availability of resources is the main issue in provision of affordable housing (Wallbaum, *et al.,* 2012:354). In the case of the housing deficit, this challenge means to look favourably upon the improvement of existing methods and the establishment of innovative technologies to act as drivers for higher efficiency or resource substitution. It is worthy to note that from the construction point of view this means: producing good quality construction materials and increasing material efficiency.

2.10.2. Lack of sufficient funds

The income of households in vulnerable conditions and/or informal settlements is usually one of the lowest in any economy. The marginal income of the target group has to be considered as a key limitation when thinking about construction technologies. Although the affordable housing project intends to highlight technologies that are able to produce sound results over the whole life cycle, the initial construction costs is a key driver for the implementation of a concept for this market segment. Being cost efficient is therefore a key challenge for all technologies (Wallbaum, *et al.,* 2012:354).

2.10.3: Time shortage due to urgency of demand

Bureaucratic and legal burdens frequently lead to longer time spans than needed. A clear lack of effective implementation strategies has been a major challenge that has to be tackled by the improvement of the interface between policy instruments and reality. A lot has been done in policy framework but its implementation is still lacking.

2.10.4: Shortage of skilled labour

One important role of housing production is the generation of new jobs, particularly for unskilled labour. Technologies that require a high skill level will face a significant problem in finding skilled and trained workers among the members of the target communities. Thus, technologies that require the lowest level of both skill and training will have priority.

2.10.5: Quality control

The quality of housing products is one of the most significant challenges. Building quality does not only affect the performance of the house but also its technical useful life. Thus, it is of great relevance to control and assure the quality of materials and construction products, as well as the proper utilization of materials on site.

2.10.6: Wastage due to inefficiency

The wastage of resources due to inefficient processes or tools causes an increase in investment costs of around 12%. But beyond the negative influence on costs, wastage also causes negative impacts on resource consumption. A shift from in situ construction to prefabrication and a higher standardization of workflows may result in less quality problems and lower wastage of resources (Wallbaum, *et al.,* 2012:355).

2.10.7. Lack of added-value creation

The target population is usually embossed by political and social exclusion. One key principle is to engage locals during planning and construction, another is to rely on locally available materials to ensure value addition to the housing provided. Mobilizing residents and their governments to strengthen all forms of community capital is required to apply the concept of sustainable development to low-income communities (Ha, 2007:124).

2.10.8. Quality and location

Low quality products reduce the houses' life spans and increase the need for maintenance interventions. However, the cultural, social and economic norms of the specific societies must be reflected in shelter and settlement planning. A second principle is that strategic planning covering land use, tenure, livelihoods and services have to be integrated in the method in addition to shelter construction. Otherwise, there is a danger that solutions do not become permanently valuable.

2.2.4 Summary

Affordable housing has been described in this study as houses that are genuinely sustainable and affordable for all income classes. However, the principle for measuring affordability of houses built for the low-income population is largely determined by the monthly income level of the prospective owner. Affordable housing should fit the household needs and should be well located in relation to services, employment and transport. In South Africa, provisions of affordable housing have been top on the priority of government for the low-income teeming population. This category of people are generally unable to access the housing market, and it is therefore imperative to seek a viable option in the construction of affordable housing, through better management of construction activities, use of local building materials, skills and improved technology. It was revealed that achieving affordable sustainable housing must incorporate a cost saving strategy into the building design. This section also highlights the challenges facing affordable housing construction, some of which form the issues this study intends to proffer sustainable solutions to.

2.3 STRATEGIES FOR SUSTAINABLE BUILDING CONSTRUCTION

2.3.1 SUSTAINABLE COMMUNITIES IN PERSPECTIVE

Sustainable communities are described as places where people want to live and work, now and in the future. They meet the diverse needs of existing and future residents, are sensitive to their environment, and contribute to a high quality of life. They are safe and inclusive, well planned, built and run, and offer equality of opportunity and good services for all (Maliene & Malys, 2009:427). The author further states that for communities to be sustainable, they must offer hospitals, schools, shops, good public transport, and a clean and safe environment. People also need open public spaces where they can relax and interact, and the ability to have a say in the way their neighbourhood is run. Most importantly, sustainable communities must offer decent homes at prices people can afford.

Today, there is a great emphasis on sustainable housing being an integral part of a community. This is because the housing provides the personal space of the individual, the place with which the occupant identifies basic urban existence. It is considered a place of non-service living and, at the same time, a space for privacy where private and emotional family life goes on and protected from external factors. Maliene and Malys (2009:428) describe sustainable housing using the Latin word "*rationalis*" which means clever. To Maliene and Malys (2009), sustainable housing is housing planned in a clever way. A house which is high-quality (in technical level), economical (opportunity to cover purchase and exploitation expenses for greater number of house-holds), ecological (energy saving, ecological building materials, etc.), comfortable (having in mind social aspect) and one which would better suit the needs of an individual.

New sustainable housing can be a driver of urban regeneration, and sustainable housing is an essential ingredient of any regeneration scheme. Sustainable housing stimulates physical, economic, environmental and social improvement, and the resulting enhancements in turn stimulate new investment and new opportunities, as the urban environment once again becomes full of life and enterprise (Maliene & Malys, 2009:428). Besides the aforementioned, housing premises must be set out according to the conditions of the specific locality and must meet the established technical and hygiene requirements. However, Figure 2.4 shows other important criteria for sustainable housing (Maliene & Malys, 2009:428).

Throughout the history of the South African urban redevelopment programme, housing has been a major concern. Housing has been in the lime light in all new interventions of policies of government. Over the last two decades, urban regeneration policy have both evolved and had various foci (as discussed in section 2.1.4 and 2.1.5 of this thesis). Lately, housing market renewal has shifted from a low-income housing construction to a more generalised modernisation policy, seeking the restructuring of low-income neighbourhoods in terms not only of housing quality but also of tenure.

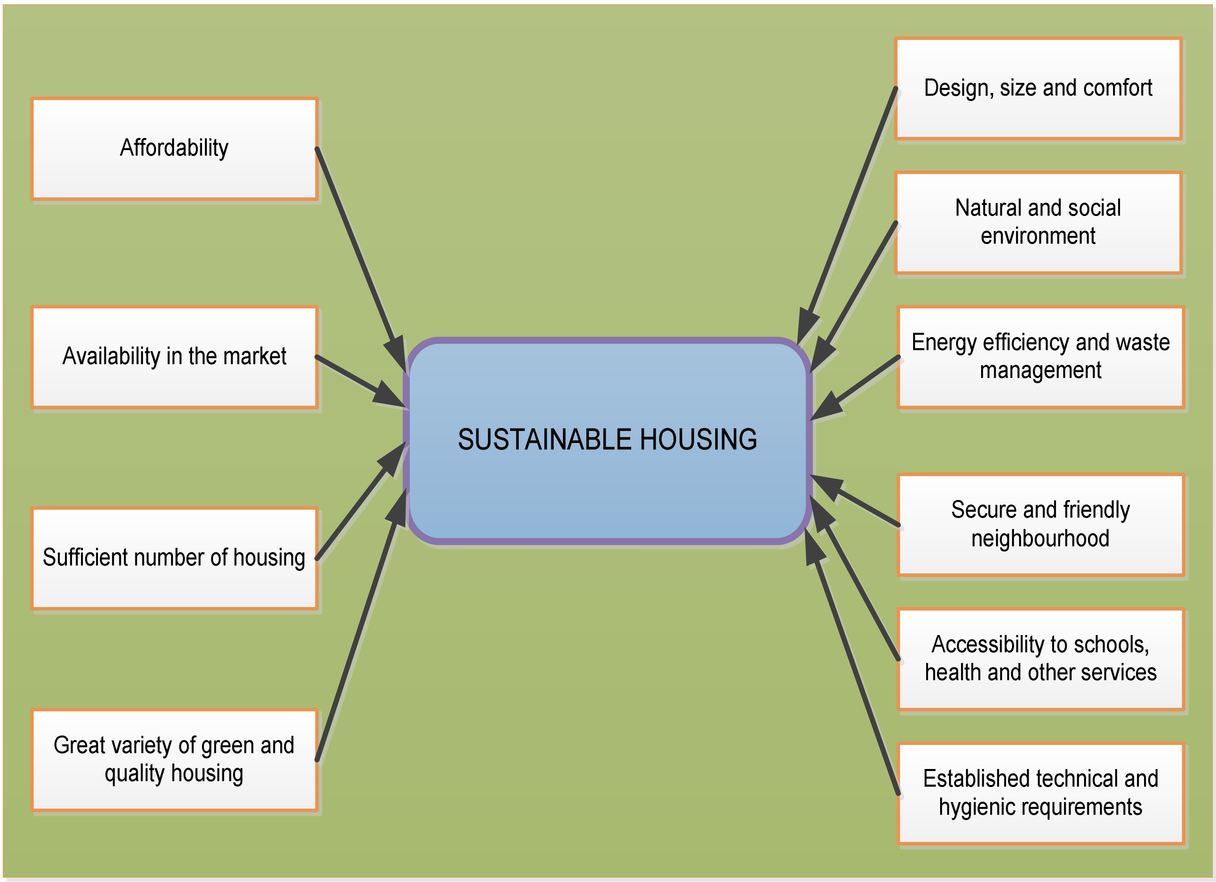

Figure 2. 4: Criteria characterizing Sustainable Housing (adapted from: Maliene & Malys, 2009)

2.3.2 DIMENSIONS OF SUSTAINABLE HOUSING APPLICATIONS

Implementation of sustainable development in low-income communities requires providing residents with affordable homes that are resource efficient, healthy and comfortable. A study conducted by Eaton in 2009 (cited in Sulivan & Ward, 2012:315) shows that energy efficiency of homes is the area of retrofitting most commonly used by government incentive programmes in the US. High-tech, renewable energy technologies, such as photovoltaic (solar) panels are not promoted in low-income, self-built or manufactured housing due to its inherent cost. However, solar panel water heaters are widely made available costing between US $1100 - $1300. The heaters comprise single solar panels that heat water to a tank that passes (or bypasses) the regular water heater tank, and can reduce a household's energy costs by 80%. In developing countries this remains a relatively high cost investment, although many of the large-scale, new social home construction projects in Mexico install solar panels on rooftops as standard. Nevertheless, much lower cost alternatives exist, such as "passive" water heaters that simply use solar radiation to heat a water tank or hosepipes to provide partially heated water at no cost. This is but one example of the range of technologies that are not only appropriate for the construction of self-built and manufactured housing, but which are also low-cost, affordable and easy to operate and maintain (Sulivan & Ward, 2012:315).

The design of sustainable housing requires a set of technologies involved with outdoor, physical environmental quality, thermal performance of the building, indoor air quality, energy system, etc. to be introduced along with the design process of residential buildings (including master planning stage, detailed design stage, and energy system design stage of residential buildings) (Zhu & Lin, 2004:1289).

2.3.3 REVIEW OF SUSTAINABLE DEVELOPMENT ASSESSMENT TOOLS

Countries around the world have developed tools for measuring sustainability for various types of development in their quest to satisfy the sustainable development agenda. Japan designs standards and guidelines for sustainable building and urbanization. The tool is called "Comprehensive Assessment System for Building Environmental Efficiency (CASBEE for an Urban Area+ Building). The United States (US) develops the rating system known as LEED (Leadership in Energy and Environmental Design) for Neighbourhood Development Rating Systems. The LEED is used to evaluate the urban development for sustainability by integrating LEED into building scale assessment for sustainable building. Accordingly, the sustainable urban development is measured in terms of the area developed according to sustainability criteria, including the environment, site/land uses, communication, transportation and the assessment of building forms for housing performance (Ding, 2008:456; Brandon & Lombardi, 2011:91; Soo Cheen & Abu Bakar, 2012:289).

Several systems for evaluating environmental performance of sustainable urban development are currently available and actively in practice around the world. The growth in the utilization of environmental performance assessment methods for new construction has contributed significantly to sustainability practices in various stages of building development. However, assessment tools have been developed with different evaluation criteria based on conditions to suit the characteristics of the countries for which the tools are designed. Table 2.1 identifies some of the rating tools employed by various countries.

Table 2. 1 Sustainable development assessment tools in various countries

No	System	Country	Year
1	CASBEE for Urban Development	Japan	2007
2	LEED for neighborhood Development	US	2008
3	RHSI (Rural Housing Sustainability Index)	Ireland	2004
4	FGBC-Green Development	Florida, US	2009
5	DDC – Sustainable Urban Site Design	New-York, US	2008
6	CI – Cercle Indicateurs	Swiss	2004
7	CEROI – Cities Environmental Reporting on the Internet Indicator Database	Czech Republic, Finland, others	2004
8	Cities21® Assessing Mutual Progress Toward Sustainable Development	Czech Republic, Finland, Latvia, Poland, others	2004
9	TISSUE – Trends and Indicators for Monitoring the EU Thematic Strategy on Sustainable	Finland, the Netherlands, UK, France, Italy, Switzerland, Czech Republic	2004
10	SURPAM – Sustainable Urban Renewal Projects Assessment Model	Hong Kong	2008
11	GBI – Green Building Index for New Residential Development and Township	Malaysia	2011

Ding (2008:456), in her assessment of sustainable construction environmental assessment tools, expressed her worry for non-inclusion of cost parameter in assessment in evaluation framework tools such as BREEAM, BEPAC, LEED and HK-BEAM. Ding (2008) further stressed that this may contradict the ultimate principle of a development, as financial return is fundamental to all projects because a project may be environmentally sound but very expensive to build. Therefore, the primary aim of a development, which is to have an economic return, may not be fulfilled, making the project less attractive to developers even though it may be environment friendly.

Brandon and Lombardi (2011) noted that a wide range of sustainability evaluation approaches are available for use in planning, design and construction, but little agreement exists among the theoretical framework to be used. Moreover, Abu-Bakar and Soo Cheen (2013:488) evaluate the performance of some of the tools listed in Table 2.1, using fifteen sustainability criteria. The authors, however, reveal that the tools are most widely used in assessment of site, indoor environment, energy, material resources and water. The less improtant criteria are the indoor environment, long-term performance and functionality, and the least important are the design aesthetics and comfort (Abu Bakar & Soo Cheen, 2013:488). From the aforementioned, it was established that sustainability in construction has remained a difficult task to fully evaluate in the broad sense, hence the necessity to develop a task specific model for assessment of sustainability in construction projects.

2.3.3.1 Cost-benefit analysis

Cost-benefit analysis (CBA) is an appraisal technique widely applied to aid the decision-making process in the early stages of a construction project's development. The purpose of undertaking CBA is to determine the viability of a project, to decide whether to build or not to build. It helps to determine the availability of funding and resources needed for the project (Ding, 1999). CBA sets out to measure and compare the total costs and benefits of different projects that are competing for scarce resources by means of a market approach. Thus, it can be used to determine which of the possible projects to finance in order to maximise the return from a given amount of capital or public resources.

There are two types of CBA: economic and social. Economic analysis involves real cash flows that affect the investors. Social analysis involves real and theoretical cash flows that affect the overall welfare of the society. The main components of CBA are project costs and project benefits. Project costs are all expenditure incurred by the developer in implementing the project. They are broadly divided into development and operation costs. The development costs refer to the expenditure for construction of a project. It includes land acquisition costs, relocation costs, construction cost and other statutory charges. Operation costs begin when the project finishes on site, and are consumed during the operation period, which include cost-in-use, maintenance and repairs, etc. However, total project cost goes beyond the cost incurred during construction, it includes costs to the community in terms of environmental quality and impacts.

Projects benefits to a developer may be revenues received from the project. Nevertheless, benefits of a project should go beyond the actual benefits expressed in monetary terms to take into account environmental issues such as better living environment, leisure facilities and better traffic arrangements (Brandon & Lombardi, 2011:102). Benefits from an economic point include productivity and employment opportunities in the community, although, author such as Ding (1999) have opined that it is difficult to place a monetary value on the social benefits.

In summary, the CBA neither theoretically nor empirically accounts for environmental sustainability objectives in a satisfactory way. Hence, the need to replace CBA with alternative techniques that do not require valuing environmental cost, or to supplement CBA with techniques that measure environmental cost other than in monetary terms.

2.3.3.2 Multi-Criteria Analysis (MCA)

MCA is a family of techniques designed to manage decisional processes typically characterised by many assessment criteria. MCA attracts increasing attention due to the fact that environmental impacts are difficult to assess in economic terms within the CBA approach framework. The advantage of MCA is that it makes it possible to consider a large number of data, relations and objectives (often in conflict) which are generally present in a specific, real-world decision problem.

Finding a solution in a multi-criteria problem is a far from easy task. The presence of several conflicting criteria makes it difficult to find an ‘optimum’, which is a solution presenting the best score with all criteria taken into account. However, the robustness of a MCA result depends on the information feeding into the selected criteria, the priorities given to the criteria (weights or importance) and the extent to which stakeholders commonly agree upon these weights.

A large number of MCA methods exist to rank, compare and/or select the most suitable policy options according to the chosen criteria. These methods distinguish themselves through the decision rule used (compensatory, partial-compensatory and non-compensatory) and through the type of data they can handle (quantitative, qualitative or mixed). In principle, each criterion to order policy alternatives can be measured quantitatively or qualitatively. Some MCA methods are designed to process only quantitative information on criteria (weighted summation). However, this disadvantage is not very significant because a well-chosen method of standardisation, such as goal standardisation, can be used in the weighted summation of the scores. The use of MCA as a preferred method depends on the decision rule and the type of data available (Brandon & Lombardi, 2011:107).

2.3.3.3 Life Cycle Assessment (LCA)

LCA is a systematic set of procedures for compiling and examining the inputs and outputs of materials and energy and the associated environmental impacts directly attributable to the functioning of a product or services system throughout its life cycle. The life cycle is considered to include the consecutive and interlinked stages of a product or service system from the extraction of natural resources to the final disposal. Brandon and Lombardi, (2011:110) classified the interlinked components of LCA into four:

1- Goal definition and scoping: identifying the LCA's purpose and the expected outputs from the analysis; determining the boundaries in terms of what is and is not to be included in the analysis and assumptions based upon the goal definition.

2- Life Cycle inventory: quantifying the energy and raw materials inputs and environmental releases to air, land and water associated with each stage of the life cycle.

3- Impacts analysis: assessing the impacts on human health and the environment associated with the consumption of energy and raw materials and the associated environmental releases as quantified by the inventory.

4- Improvement analysis: evaluating the opportunities to reduce energy, material inputs (e.g. through resources efficiency measures or recycling) and the environmental impacts at each stage of the product life cycle.

It is worthy to note that LCA allows clear comparisons between product systems, leading to greater understanding of the way in which environmental impacts are generated. However, some of LCA's weaknesses are; lack of systematic consideration of the economic and social impacts, and the costly and time-consuming procedures involved.

2.3.4 HOUSING DEVELOPMENT AND SUSTAINABILITY

Previous researches on sustainability in housing construction have shown that houses built in the past decade did not meet the essential criteria of sustainability. Notably, Brandon and Lombardi (2011:119) opine that building design did not take into account energy efficiency in the design of green affordable housing. The author noted that building green housing requires specialized designs that specify the purpose of the building installations and requirements relating to building structures, and the calculation of projected energy use of proposed buildings. Also, building professionals required skills and experiences, such as extensive residential construction experience, drafting experience, building science backgrounds, indoor air quality investigation training, mechanical ventilation training and other related skills (Kibert, 2005).

Sustainability of housing development gives more emphasis to environmental, economic and social issues. Construction itself creates a variety of environmental problems, such as greenhouse gas emission and environmental pollution, mainly because of the materials used, nature of design, methods of construction, locations and layout, physical structure and the use to which buildings are put.

2.3.5 SUSTAINABLE BUILDING CONSTRUCTION METHODS

There are frightening revelations on the importance of the built environment to any policy and evaluation of environmental sustainability. Nevertheless, the construction and use of a building is an important factor in the overall sustainable development motives. However, to achieve sustainability in housing construction, certain factors must be considered in the choice of construction methods, and the construction methods that satisfy some of these criteria are best used for the construction of affordable houses.

2.3.5.1 Lean construction

Lean construction results from the application of a new form of production management to construction. Essential features of lean construction include a clear set of objectives for the delivery process, aimed at maximising performance for the customer at the project level, concurrent design, construction, and the application of project control throughout the life cycle of the project from design to delivery (Aziz & Hafez, 2013:679). Lean production has been in use since the 1950s and was implemented by the Toyota Motor Company in its production line (also known as Toyota production system principles) (Koskela, 1992:5; Green, 1999:133). The Toyota production system had two pillar concepts: (1) Just-In-Time flow (JIT) and (2) Automation (smart automation), shown in more detail in Figure 2.5. The term “lean” was coined by the research team working on international auto production to reflect both the waste reduction nature of the Toyota production system and to contrast it with craft and mass forms of production (Green, 1999:133; Aziz & Hafez, 2013:680).

The adoption of lean thinking came into focus due to a decline in efficiency of the construction industry over three decades ago (Koushki, Al-Rashid & Kartum, 2005; Sacks & Goldin, 2007; Guo, 2009; Arditi & Mochtar, 2000:16). These authors attributed the decline to the inability of new construction techniques to effectively reduce the cost of construction and design, while still improving the management process. However, lean construction, if fully integrated into the construction process, has great potential for reducing cost (Green, 1999:136).

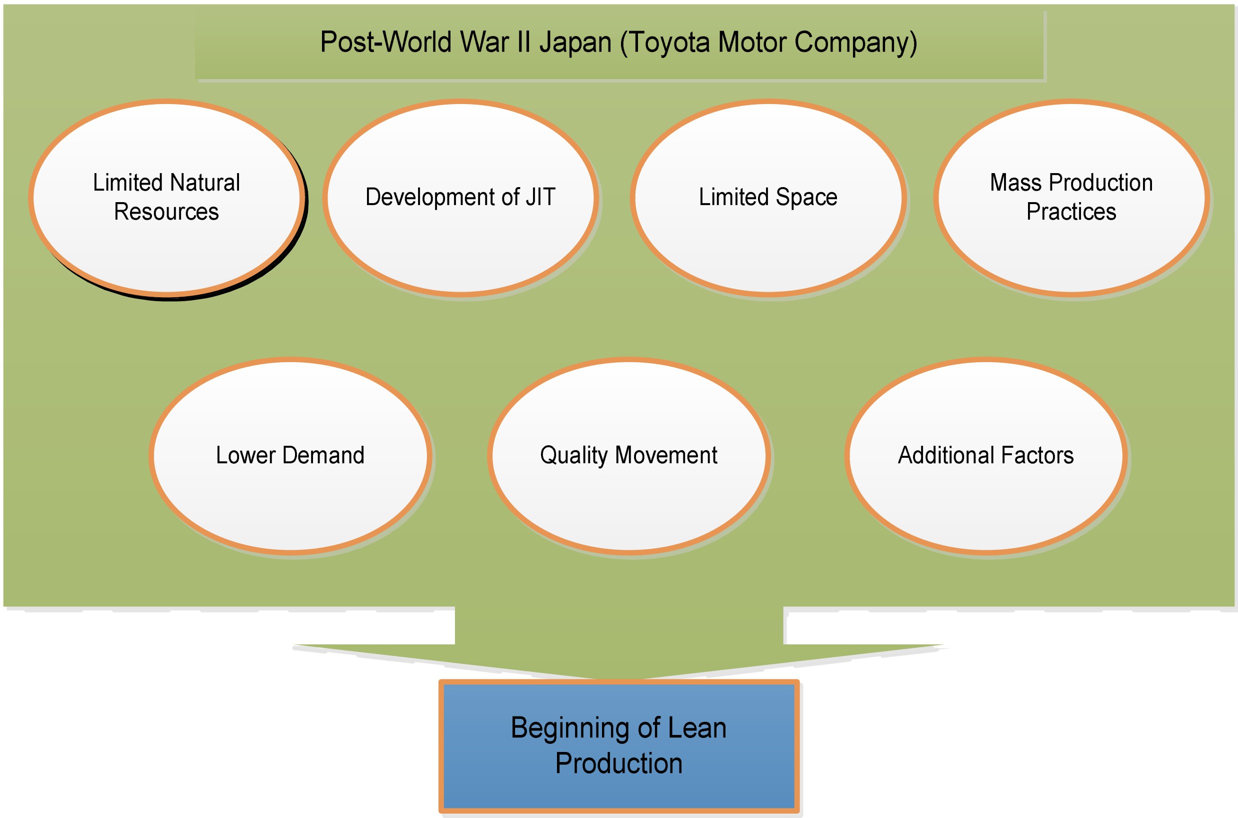

Figure 2. 5: Beginning of Lean production (Adapted from Aziz & Hafez 2013)

Lean production aims to design and make things different from mass and craft forms of production by redefining the objectives and technique, to optimize performance of the production system against a standard of perfection to meet unique customer requirements. Koskela (1992:31) reported the adaptation of lean production concepts in the construction industry and presented a production management paradigm where production was conceptualized in three complementary ways, namely; (1) Transformation; (2) Flow; and (3) Value generation (TFV theory of production). This tripartite view of production has led to the birth of lean construction as a discipline that subsumes the transformation-dominated contemporary construction management (Koskela, Huovila, & Leinonen, 2002; Bertelsen & Koskela, 2002). Managing construction under lean concepts is different from typical contemporary practice because; (1) it has a clear set of objectives for the delivery process; (2) it is aimed at maximising performance for the customer at the project level; (3) it designs concurrently product and process; and (4) it applies production control throughout the life of the project. In lean construction, as in much of manufacturing, planning (defining criteria for success) and control (ensuring events conform to plan, and triggering learning and re-planning) are two sides of a coin that keeps revolving throughout a project.

2.3.5.1.1 Lean thinking principles

There are five fundamental principles according to (Bashford, Walsh and Sawhney, 2005; Hook & Stehn, 2008; Deshpande, *et al*., 2012; Aziz & Hafez, 2013) which have to be followed systematically to gain the maximum benefit of lean thinking:

(1) Specify Value: Specify value from the customer's own definition, needs and identify the value of activities, which adds value to the end-product.

(2) Identify the Value Stream: Identify the value stream by elimination of everything which does not add value to the end-product. Processes which have to be avoided are miss production, repeat production of the same type of product, storage of materials and unnecessary processes, transport of materials, movement of labour workforces and products, production of products which does not live up to the desired standard of the customer, and all kinds of unnecessary waiting periods.

(3) Flow: Ensure that there is a continuous flow in the process and value chain by focusing on the entire supply chain. Focus has to be on the process and not at the end product. However, the flow will never be optimal until customer value is specified, and the value stream is identified.

(4) Pull: Use pull in the production and construction process instead of push. This means produce exactly what the customer wants at the time the customer needs it, and always be prepared for changes made by the customer. The idea is to reduce unnecessary production and to use the management tool "Just In Time".

(5) Perfection: Aims at the perfect solution and continuous improvements. Deliver a product which lives up to customer's needs and expectations within the agreed time schedule and in a perfect condition without mistakes and defects.

Authors such as Hook and Stehn (2008:22), and Aziz and Hafez (2013:684) attest that the lean approach mainly focuses on project performance improvements through tools and techniques in terms of project settings. Figure 2.6 summarizes examples of lean tools already used in job sites (Aziz & Hafez, 2013:684). However, Lean Construction is best achieved through a simultaneously top-down / bottom-up approach. A bottom-up (person focused) approach implies workers using specific working routines, thereby forming the culture where lean tools can improve how the traditional things are done (Hook, & Stehn, 2008:22). The only way to do so is by having a close communication with the customer/client as well as managers and employees.

Koskela (1992:16) summarizes lean thinking into eleven principles which are: (1) Reduce the share of non-value adding activities (waste); (2) Increase output value through systematic consideration of customer requirements; (3) Reduce variability; (4) Reduce cycle times; (5) Simplify by minimizing the number of steps, parts and linkages; (6) Increase output flexibility; (7) Increase process transparency; (8) Focus control on the complete process; (9) Build continuous improvement into the process; (10) Balance flow improvement with conversion improvement; and (11) Benchmark. Meanwhile, the Construction Industry Institute (CII, 2007) classifies fourteen lean principles into four categories: (1) Philosophy; (2) Process; (3) People and Partners; and (4) Problem Solving.

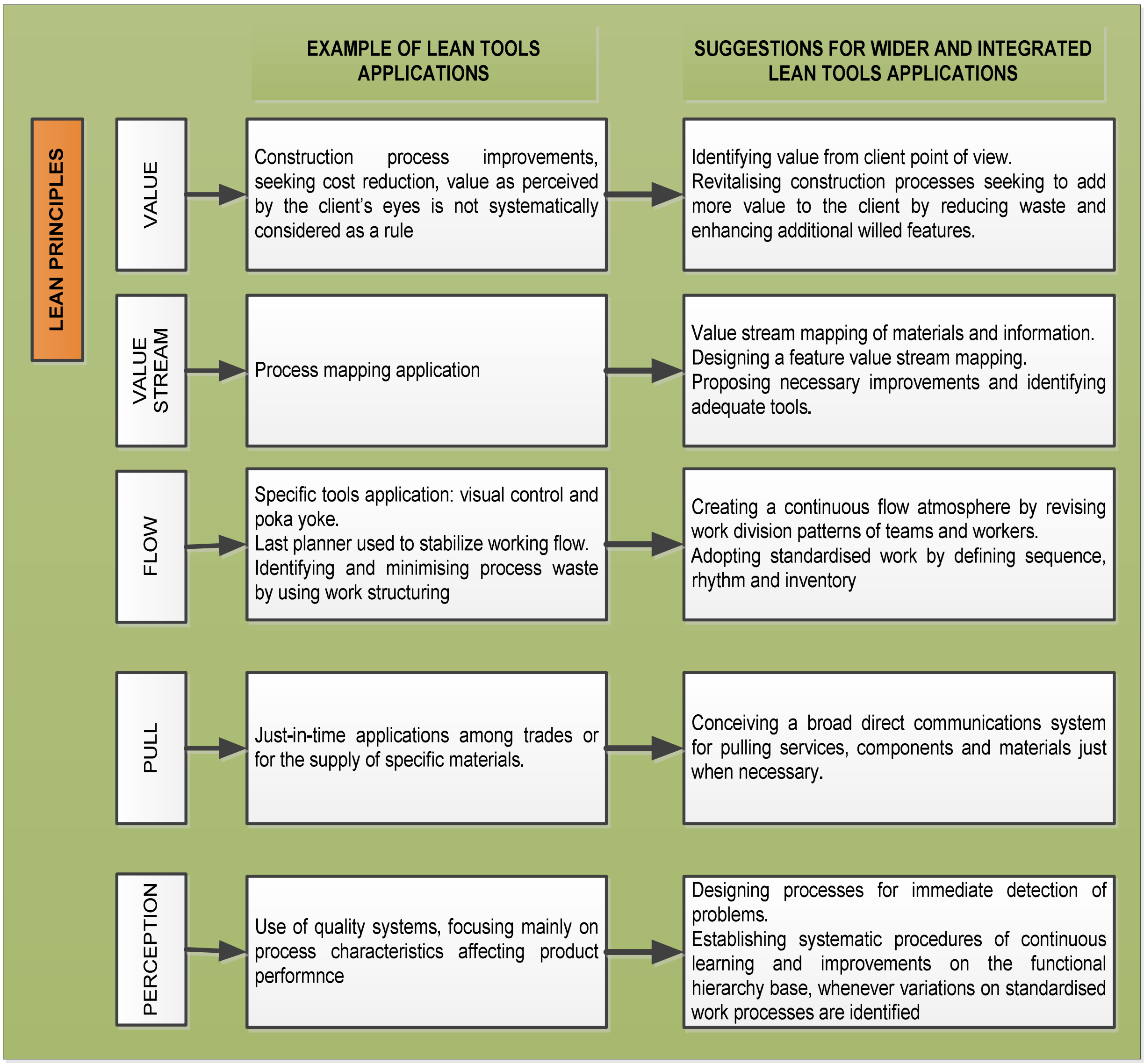

Figure 2. 6: Examples of lean tools in construction implementation and suggestions (adapted from Aziz, & Hafez, 2013)

2.3.5.1.2 Lean construction techniques

Lean construction is a way to design production systems to minimize waste of materials, time and effort in order to generate the maximum possible amount of value (Koskela, Huovila & Leinonen, 2002). The most important aspect of lean conceptualization is the identification of non-value adding wasteful activities in design and eliminating the non-value adding activities in the building design to generate value for the client (Deshpande, *et al.,* 2012:221).

Lean construction is using the same principles as lean production to reduce waste and increase the productivity and effectiveness in construction work. The most important determinants of construction are supposed to be workflow reliability and labour flow, but lean construction has changed the traditional view of the project as transformation, and embraces the concept of flow and value generation (Bertelsen, 2004:52). Similarly, it shares the same objectives of lean production, e.g. cycle time reduction, elimination of waste, and reduction in cost of building materials which, according to Bertelsen (2004:52), accounts for two thirds of construction cost. Continuous improvement, pull production control, and continuous flow have been the direction for the implementation of lean construction.

According to the Lean Construction Institute (2004), for a project to be managed using the lean approach, the management process must be defined as follows: (1) Determine client requirements and design to meet them; (2) Align design to quality, schedule and budget limits; (3) Manage the project by breaking it into pieces, estimating duration and resource requirements for each piece, and then putting the pieces in a logical order with the Critical Path Method (CPM); (4) Assign or contract for each piece, give start notice and monitor each piece to assure it meets safety, quality, schedule and cost standards. Take action on negative variance from standards; (5) Coordinate using the master schedule and weekly meetings; (6) Cost may be reduced by productivity improvement; (7) Duration may be reduced by speeding each piece or changing logic; and (8) Quality and safety get better with inspection and enforcement.

2.3.5.1.3 Application of lean principles in residential design and construction

Design and construction of mass housing presents a unique challenge in terms of managing the building process. Overcoming the challenge requires essential notions of the lean production system, such as waste reduction, and continuous improvement to design by conceptualizing design in three different ways: design as conversion of input to outputs, design as a process of flow of information, and design as a process of a value generation (Deshpande, *et al*., 2012:221). Moreover, Deshpande, *et al.,* (2012:221) explain that the lean design process involves a group of specialists who transform the perception of the client’s requirements (input) into design decisions and implementable design documents (outputs). It is important to note that excessive emphasis on conceptualizing the design process as a conversion of inputs to outputs can result in a large incidence of non-value adding activities in the design process, resulting in long duration and insufficient time for generating design solutions.

However, improvement in quality of building design is dependent on the amount and quality of information about client needs and requirements. This is achievable through; systematic evaluation of client requirements, reducing variability in the design process, reducing approval cycle times for design documents, focusing on the complete design process using stage gates within design, benchmarking with other similar projects for systematic performance evaluation, and building continuous improvement in the design processes.

2.3.5.2 Concurrent Engineering Construction Method

Concurrent Engineering (CE) is a management philosophy originating from the manufacturing industry. There are many definitions of CE in the literature but most of the definitions are similar. The term "Concurrent Engineering" was originally devised by the Institute for Defence Analysis (IDA), a working group set up by the US Defence Advanced Research Project Agency (DARPA) in their Report R-138 (Winner *et al*. 1988 cited in Mohamad, Baldwin, & Yahya, 2008:1). The Concurrent Engineering construction method is defined as a construction process that utilises techniques, products, components or building systems involving the use of on-site and off-site (factory producing) prefabrications for installation. The on-site pre-casting consists of floor and roof slabs in situ, whereas the off-site fabrications of some or all components of buildings are cast off-site at fabrication yards or factories. With the transfer of construction operations to factories or fabrication yards, good quality components have been mass-produced and delivered to the construction sites in economically large loads (Badir & Kadir, 2002:22). In addition to this definition, the IDA definition of CE is the most widely accepted by the manufacturing community. IDA thus defined CE as:

> *"A systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from concept through disposal, including quality, cost, schedule, and user requirements".*

The rationale for the application of CE to construction derives from the similarity of the basic construction/manufacturing process as well as the nature of the problem faced by both industries, because of the traditional approach practised in its work process.

Although, there is no research evidence to support that it has been fully applied in construction to the same extent as in other industries (Love, Gunasekaran & Li, 1998). Application of CE and its fundamental elements to construction has generated some interest in extant literature by De La Garza *et al*., (1994); Baxendale *et al*., (1996); Evbuomwan & Anumba, (1996); Houvilla, *et al*., (1997); Love *et al*., (1998); and Kamara, (1999). However, the consensus among these authors is that CE is considered suitable for application in construction.

Therefore, considering the importance of the following CE philosophy to construction, the benefit of employing CE for housing construction cannot be overemphasised:

- **Consideration of project life cycle requirements in the design process**: In the simplest form, the construction process can be divided into two major phases; pre-contract and post contract. Pre-contract activities include briefing, feasibility, sketch design, design, tendering; and post contract activities include construction and maintenance of facilities. Applying the CE principle to construction means that all the project life-cycle requirements, such as planning, construction, end user requirements, maintenance requirements, constraints by major suppliers, sub-contractors, and specialist contractors, must be simultaneously (concurrently) considered during the design development phase. Input from the functional expertise from all the various organisations in the project has to be considered in the design from outset.

The traditional construction process is based upon the separation of the design and construction functions. Therefore, consideration of the downstream requirements cannot be fully realised during the design phase because of the lack of participation from the constructors and other parties. Due to this constraint, it is common for the construction project to experience design related problems in the latter stage of the project.

- **Teamwork:** The use of teamwork is a common approach in today's management practice. It is also a common practice to organise a project team prior to the execution of the construction project. The concept of teamwork used in CE principles is based on a collaborative teamwork system or more appropriately known in CE practices as Cross Functional Team (CFT). Teamwork is the backbone of CE (Jo, *et al.,* 1993). The formation of the team concept is an important feature that characterises the relationship between the various participants within a construction project. However, the degree of the relationship among the members of the team in the traditional construction project is different from the teamwork concept of a cross functional team (CFT), as proposed in CE philosophy. In general, the project team concept in the traditional construction process involves owner and/or his representatives (designers and contractors) engaged in a temporary organisation to execute the project task, and is guided by the requirements of the contract. In a CE environment, the formation of the team must involve all the major stakeholders. In construction this includes; the owner; the designer; constructor (contractor), sub-contractor; customers and suppliers. All these parties must work as a team and the initial stage of the team formation must be at the outset of the project.

- **Lead-time:** The reduction of lead-time in manufacturing is important to enable the product to reach the market as soon as possible. In construction, reducing development time is equally important. Most projects have the urgency to be completed in the planned time so that the return from investment can be earned as soon as possible. Therefore, the objective of CE to reduce product development time is very appropriate in the construction industry scenario. In CE, reduction of development time is achieved by simultaneously considering all life cycle requirements in design development. This strategy leads to reduction of the unnecessary time needed to rectify design error and rework. It also enables parallel accomplishment of project tasks because of early involvement of team members and the ability to share more project information across the functional boundaries.

- **Focus on the customer requirements:** The common approach normally used in CE to capture customer requirements is by their inclusion in the project team and use of techniques such as Quality Function Deployment (QFD). The initial client requirements in the construction project are addressed at the briefing stage. Clients will be involved in the project team throughout the project life cycle.

2.3.5.2.1 Benefits of Applying CE to Construction

Currently construction has gained the benefit of implementing some of the elements that are parallel to CE through design and build procurement approach, fast track system and partnering approach. Nevertheless, the benefit gained through these partial or 'unintentional' approaches toward CE is limited. This can be greatly amplified if it is applied as a whole process as it is in manufacturing. The most important benefit from the application of CE to construction lies within the capability of the CE philosophy to support process change. Construction has suffered from the setback of traditional practices, which has resulted in many problems. Therefore, there is an urgent need for the industry to realign the traditional way of delivering the project with respect to the work process and the teamwork structure. Fragmentation and specialisation is a natural phenomenon in construction. However, applying CE principles will help to tear down the invisible wall that separate these fragmented functional organisations (groups) and pull them together into a solid collaborative team, sharing the same project goals and objectives.

Furthermore, all the different expertise from various functional groups will enjoy the opportunity to contribute their input and queries toward design development. Another important benefit of applying CE to construction is the ability to reduce lead-time in product development. Project delay is very common in construction, therefore the industry should consider adopting CE as a strategy to minimise the problem. De La Garza, *et al*. (1994) reported the result of a study on CE implementation in Europe and the outcome shows; 30% - 42% reduction in manufacturing cost; 75% reduction in scrap and rework; 35%-60% reduction in time to develop an artefact; 30%-87% reduction in defects; and 30%-60% increase in saving. This study, although not carried out on construction, presents the idea of the array of benefits that construction can expect from CE implementation. Evbuomwan and Anumba (1998) suggest that applying CE will have the following benefits to construction: Implementing CE will enable the establishment of a formal framework to identify client's requirement at the outset. CE will help to reduce error, rework and duplication of work that is normally incurred in the conventional (traditional) procedure. This will result in: shortening lead time; reducing cost and project delays; drastically reduced claims and dispute; and ensure savings on project cost. Apart from that, the application of CE also ensures concurrent design and construction in an integrated project model, and improve the technical capability of the project team through the enhanced knowledge base and better informed design decisions.

2.3.5.3 Traditional Construction Method

This method consists of extensive cast in situ activities. Reinforced concrete frames, beams, columns, walls and the roof are cast in situ using timber formwork, while steel reinforcement is fabricated at site. It is labour intensive involving three separate trades, namely steel bending, formwork fabrication and concreting: employing skilled carpenters, plasterers and brick workers.

Coimbra and Almeida’s (2013:9) study of cooperative housing developments in Portugal presented the first house with characteristics of traditional construction and the second including sustainable building features to demonstrate that it is possible to build below cost limits imposed by law to reduce energy consumption costs for heating and cooling as well as for domestic water heating substantially. According to the study, the cost increase by using very efficient techniques of insulation of the envelope is 4.2% of the construction cost and the decrease of heat loss achieved varies from 30% (according to consumptions) to 60% (according to energy needs) when compared with traditional construction (Coimbra & Almeida, 2013:16). A similar study by Tam (2011:159) examined the cost effectiveness of using low cost housing technologies in comparison with the traditional construction methods, using two case studies in India. It was found that about 26.11% and 22.68% of the construction cost, including material and labour cost, could be saved by using the low cost housing technologies in comparison with the traditional construction methods for walling and roofing respectively.

2.3.5.4 Modular Construction Method

An intermediate construction method is defined by the use of certain elements that are standardised and fabricated in the factory while others are cast in situ at the construction sites. This involves the assembly of precast elements, such as in-filled walls, bathrooms and staircases, which are incorporated into the main units at the construction sites. Floors, slabs, columns and beams are cast in situ as these are relatively easier and less time-consuming parts of the operation (Badir & Kadir, 2002). Ahadzie, Proverbs and Olomolaiye (2008:684) noted that prefabrication and industrialisation have also been widely considered in housing projects in the name of improving overall time and cost associated with these projects. The authors further express that other innovative methods, such as modular boxes, pre-stressed panels and polystyrene, have also been advocated.

2.3.5.5 Comparing Waste Minimisation among Sustainable Building Construction Method

The term construction and demolition (C&D) waste is generally referred to as solid waste generated by the construction sector arising from civil and building construction, building renovation and demolition including activities such as land excavation or formation, site clearance and roadwork (Shen, Tam, Tam, & Drew, 2004:474; Yuan, Shen, Hao, & Lu, 2011:604). Shen, *et al.,* (2004) reported that globally, significant amounts of construction and demolition (C&D) waste are generated annually. The authors stated that in 2003, approximately 323 million tons of C&D waste was generated, and this was buttressed by Vatalis, Manoliadis, Charalampides, Platias and Savvidis (2013), that building materials and components from construction or demolition that are often discarded with construction debris account for 28% of landfill waste in USA. In the UK, the figure stood at approximately 70 million tons, which included soil with a material wastage rate of 10% – 15%. The Environment Protection Department (EDP) of Hong Kong has estimated that landfills in Hong Kong received about 3158 tons of construction waste per day in 2007 (Hong Kong EDP, 2007 cited in Lachimpadi, Pereira, Taha & Mokhtar, 2012:97) whereas in China, C&D waste accounted for approximately 40% of the total Municipal Solid Waste (MSW) composition (Wang, Kang & Tam, 2008:234).

A study conducted by the World Watch Institute has shown that the raw material used for building construction consumes up to 40% of stones, sand and gravel; 25% of timber; and 16% of all water used annually around the world (Lachimpadi, *et al.,* 2012:97). Based on the quantities of raw materials used by the construction industry, it is responsible for generating a significant portion of construction waste in the world (Kourmpanis, *et al.,* 2008:272). In recent years, there has been a concerted move to promote the reuse and recycling of construction waste in order to reduce inflow of construction waste into the landfills and to protect the environment (Lachimpadi, *et al.,* 2012:98). In RSA, the construction industry's impact on the environment is significant due to the high demands in major infrastructure projects, housing and commercial developments generating high volumes of construction waste. This has aroused the public's growing concerns on negative environmental impacts in South Africa. In recognising these concerns, RSA government established the GBCSA; one of its aims was to transform the construction industry by improving its environmental performance through reinforcing the construction industry's commitment to sustainable development. Other countries within the African continent, such as Egypt, established the "Green Pyramid Rating System" which emphasised on waste management, particularly on site provision and environment, which contributes to 75% of the management score (Abdelhamid, 2014:317).

To achieve sustainable construction, the need to adopt construction methods that have greater efficiency to reduce construction waste to the lowest minimum cannot be overemphasised. The Concurrent Engineering Method (often called Industrialised Building System) is widely used in Europe, Japan and Singapore, and is seen as an alternative option to the Traditional (Conventional) Construction Method in maintaining sustainability in construction through the efficient use of resources, improvements in the quality of constructed buildings and waste minimisation (Tam, Tam, Zeng & Ng, 2007:3653; Begum, Satari & Pereira, (2010:384). A study by Begum *et al*., (2006) at a construction site where the Concurrent Engineering method was used in Malaysia showed that 73% of construction waste was reused and recycled; indicating the economic feasibility of waste minimisation through adoption of concurrent engineering and the net benefit calculated in the study was valued at 2.5% of the total project budget.

A study by Lachimpadi, *et al.,* (2012:99) viewed generation of soil as waste (soil and sand) which greatly depends on the design of the buildings and its landscaping requirements. Lachimpadi, *et al*., (2012:99) further express that the project requirements dictated the blend of constructed buildings into the natural contours of the surrounding environment. This required higher cut rates compared to the fills, resulting in surplus soil that was classified as soil and sand waste. The soil and sand waste in the traditional construction method is averaged at 15%, the other fractions of the mineral components bricks and blocks (3%), tiles (1%) and scrap metal (2%). A study by Lachimpadi, *et al.,* (2012) shows that concrete and aggregate waste in the traditional method was reduced by half when compared to the waste generated under concurrent engineering and modular construction. This reduction was achieved by the use of e.g. pre-cast panels to replace the more traditional brick laying for wall construction and other building structures.

2.3.6 HOUSING FINANCING CONCEPTS FOR SUSTAINABLE DEVELOPMENT

An obstacle in the provision of low-income housing is the difficulty encountered by commercial banks to extend loans to the poor population in the housing market, despite supporting initiatives by Government. A lack of knowledge on the borrowing behaviour, preferences and experiences of low-income households in accessing housing finance from the commercial banking sector in South Africa hampers an understanding of the reasons for these problems (Pillay & Naude, 2006:873; Tomlinson, 2007:77). South Africa is facing a low-income housing crisis, with the current backlog estimated at over three million units.

The South African housing finance system suffered defaults on home loans that were precipitated by political boycotts and civil disobedience prior to 1994. These occurrences brought municipal service delivery to a halt and caused serious loan defaults for the commercial banks that were providing home loans to the low- and moderate-income households of South Africa (Pillay & Naude, 2006:873). As at 1994, commercial banks, together with the state-owned mortgage lender Khayalethu Home Loans, had on their portfolios approximately 34,000 properties in possession because of nonperforming loans (Banking Council, 1999:15). The inability to effectively and efficiently evict residents that defaulted on payments ultimately caused the lenders to withdraw from the low-and moderate-income segment of the housing market. This led to the collapse of mortgage financing opportunities for low-income earners in the housing market.

Home ownership has captured the attention of policymakers across the globe in recent years, and this attention has often been negative. Bank failures, based on failed home mortgages and a nearly worldwide housing recession, have raised difficult questions about the viability of pro-ownership public subsidies. For example, in the US, high foreclosure rates have provoked a debate over using limited federal resources to promote home purchases (Beracha & Johnson, 2012; Davis, 2012; Shlay, 2006). Yet, the demand for buying a home remains strong, even among households most exposed to the negative outcomes of failed home ownership (Drew & Herbert, 2012). The lure of owning a home remains part of the social and economic fabric of families and communities (Hui, Yu & Ho, 2009). There has been vigorous debate about the optimal role of government in subsidising housing construction in stimulating the economy and the role of mortgages in the financial sector. But a common theme is the concern about how to best aid low-income first-time home buyers.

2.3.6.1 Housing Subsidy Financing Scheme

After the collapse of mortgage financing for low-income housing in 1994, the newly elected government initiated a multi-pronged approach to induce mortgage lenders to provide financing to the low-income market. A capital subsidy scheme was implemented to kick-start the low-income housing market. The capital subsidy scheme was originally managed via the Provincial Housing Boards (PHBs) and in the year 2000, the Government decided to de-establish these structures and make the Provincial Member of The Executive Council (MEC) responsible for the subsidy allocation. One million subsidies were allocated from 1995 to 2001. Some 90% (CSIR, 2000:18) of these were allocated to people earning less than 1500 South African Rand (ZAR1500) per month, 8% to people earning between ZAR1501 – ZAR2500 per month and the remainder to those earning less than R3500 per month (South African National Department of Housing, 2001; Pillay & Naude, 2006:874; Tomlinson, 2007:78).

According to Gilbert (2004:13), capital housing subsidies have reduced housing problems in South Africa. However, there are concerns on the long-term sustainability of tackling housing problems in this way in the face of high unemployment, huge income inequality and widespread poverty (Gilbert, 2004:13). Problems and constraints in financing low-income housing are wide-ranging and have been argued to include distortions caused by the withdrawal of developers from low-income market, inefficient deployment of government subsidies, and the inability of national development finance institutions to absorb higher risks, particularly in areas where there is market failure (Pillay & Naude, 2006:874).

One major problem that characterise Capita Housing Subsidies was the immediate development of housing queues. In South Africa, the delivery of 1.13 million subsidies by the end of the year 2000, failed to cut the long list of applicants. Another common criticism of the housing provided through subsidy has been its poor location. The distribution of subsidies between regions has been uneven and most of the homes built in the larger cities have been located far from the main centres of employment. Some critics have even alleged that the policy has accentuated social segregation (Gilbert, 2004:27). Many commentators have criticised the new kinds of official slum being created by the subsidy programme. The government's success in providing housing for the very poor has produced ghettos of unemployment and poverty. Many of the new owners cannot afford to maintain the accommodation or pay the charges for their water and electricity, some criticise the new owners for trading in the subsidy for quick cash, others believe that the cause lies in the fact that the beneficiaries cannot actually afford to live in the new housing (Gilbert, 2004:27).

However, since the return of democratically elected South African government in 1994, ''*the government, in partnership with housing institutions, communities, the private sector and NGOs, has provided subsidies for more than 1,334,200 houses with secure tenure to the poorest of the poor in both urban and rural areas. The total number of houses that have been constructed is approximately 1,155,300, housing close to 5,776, 300 people*'' (RSA, Department of Housing, 2001:5). Every government offering housing subsidies has to resolve a basic dilemma. Given an agreed level of expenditure, does it attempt to maximise the number of subsidies and lower the standard of housing, or maintain the standard of housing but offer fewer subsidies? Clearly, efficient production and programming can increase the quality of a housing solution at any given price, but the basic trade-off is unavoidable. The building lobby and most urban planners are generally in favour of offering higher subsidies whereas the finance ministry and progressive architects and planners tend to be on the side of offering smaller subsidies. Subsequent upon the aforementioned, Gilbert (2004:23) is of the opinion that the basic trade-off between the number of subsidies and the quality of the final housing product can be masked in a number of ways. Low subsidies can be supplemented by credit, thereby raising the quality of the homes on offer. The inclusion of higher-income households, eligible only for small subsidies, will increase the number of subsidies on offer (Gilbert, 2004:23).

In conclusion, subsidies could not solve all of South Africa's housing problems but it had given homes to very large numbers of poor households. If there are problems with the homes provided, people are at least living somewhere legally (Gilbert, 2004:19).

2.3.6.2 Down Payment Grant Financing Scheme

One of the primary problems facing low-income families who wish to purchase homes is the lack of a substantial equity stake in the loan. To deal with this problem, many government programmes offer grants and low-interest loans specifically to provide borrowers with a sufficient down payment to obtain a loan. Grants may also be available to pay for closing costs, legal fees, and other costs related to the purchase of low-cost homes. Eligibility for this type of assistance is generally limited to low and very low income families (those with incomes below 80% of the median income in their community, adjusted for family size). Individuals typically apply for this assistance directly through the sponsoring non-profit organisation or government agency; this may occur either before or after initial contact with a lender (Calomiris, Kahn & Longhofer, 1994:639).

Down payment subsidies can be structured in different ways, including grants and loans. Loans ideally result in the repayment of capital that is then re-used as a down payment loan for another borrower. These loans can be amortizing, but most often are designed as “silent” junior liens due at resale or refinance. Because these loans tend to be small, they must be monitored over many years, and lose value with inflation. The costs of administering these loans are high relative to the loan amount. Additionally, subsidies in the form of junior liens can constrain owners from taking out additional loans. Instead of loans, some assistance programmes use down payment grants, which are administratively efficient but strictly one-time in nature.

2.3.6.3 Mortgage Payment Subsidies Financing Scheme

Mortgage Payment subsidies are housing financing programmes that effectively reduce the interest rate or other periodic payments made by an individual or organisation that has borrowed money directly associated with some housing project. These programmes include direct lending to organisations that participate in providing housing for low- and very low-income families. Except in the case of a subsidy scheme, most recipients of mortgage payment subsidies apply for this assistance directly through the sponsoring non-profit organisation or government agency. However, many of the programmes (especially direct loans) are limited to individuals and organisations that are unable to obtain private financing without this assistance. This restriction affects the market in which loans are made and the incentives of the lenders (Calomiris, Kahn & Longhofer, 1994:640).

One of the most well-known mechanisms to reduce borrowing costs for first-time, lower-income home buyers is single-family housing bonds, known as mortgage revenue bonds

(MRBs). MRBs are sold to investors in order to finance below-market interest rate mortgages. Investors are willing to purchase these bonds at below-market interest rates because the income from MRBs is tax-free. State housing finance agencies are allocated a per-capita amount of tax-exempt housing bond authority each year. By law, MRB-backed loans are limited to first-time home buyers who earn no more than the median income in their area. If a borrower's income rises above eligible levels, up to one-half of any profit from the sale of the financed home may be recaptured for up to nine years (although in practice this rarely occurs). MRBs are administered by designated state agencies that issue the bonds and monitor loans. Because of the mechanics of issuing the bonds and the relative value of tax exempt interest, the value of MRBs to first-time buyers fluctuates over time. In general, the resulting payment subsidy is relatively low, typically less than one percentage point below prevailing market rates (Ergungor, 2010; Durning, 1987).

2.3.6.4 Mortgage Interest Deduction Financing Scheme

The mortgage interest deduction is a subsidy for home ownership delivered through the tax code. Though this financing scheme is yet to be employed in affordable housing financing in South Africa, it is by far the largest support for owning a home in the US and applies to all home owners, not just those with low incomes. Many public housing programmes provide grants to state and local governments and various non-profit and for profit organisations to help them build, rehabilitate or purchase housing for resale or rental to low-income families. Regardless of the details, each of these programmes affects the credit market by directly increasing the supply of subsidized housing available for purchase by low-income families (Calomiris, Kahn & Longhofer, 1994:640). Mortgage borrowers may deduct mortgage interest from taxable income when calculating federal income tax. This deduction can reduce tax liabilities for home buyers, and thus increase income available for monthly housing payments. The mortgage interest deduction is the second largest tax expenditure for individuals in the federal budget, after the exemption for contributions to pension funds. However, the deduction is primarily an incentive to borrow using more mortgage debt rather than an incentive for lower-income renters to become owners. Most lower-income taxpayers take the standard deduction on their federal income taxes and do not claim the mortgage interest deduction. Only 10% of tax filers with incomes under the median income itemize (Davis, 2012). The progressive nature of federal income tax rates results in lower-income owners receiving a smaller deduction as a percentage of income than more affluent buyers even if they itemize their deductions. Recent studies suggest that the mortgage interest deduction is largely capitalised into house prices (depending on the elasticity of local housing markets) and in reality is less of a support of home ownership than many policy makers assume (Glaeser, 2011); (Davis, 2012); (Bourassa, *et al.* 2012).

2.3.6.5 Credit Enhancement Financing Scheme

Credit Enhancement is a financing mechanism that does not directly provide low-cost financing, but which can overcome financing barriers. It enhances the credit-worthiness of the person or entity seeking financing by reducing or eliminating some identified risk. For example, loan guarantees and mortgage insurance are credit enhancements that reduce or eliminate risks of loss if a default occurs, thereby making loan payments more affordable. Low-cost construction loans can reduce interest costs by hundreds or thousands of dollars per unit. In syndicated rental projects, typically one-third of the equity is advanced for construction, further reducing interest carry costs. Grant financing is less commonly used, mainly for construction of public housing, housing for the elderly and homeless or home repairs for the poor.

Credit enhancements also involve additional guarantees, insurance or collateral, and increase access to capital used to finance a home. In some cases, enhancements lower the costs of borrowing and might be viewed as a subsidy to buyers. The rise and fall of government’s financial commitment for housing provision offer a cautionary tale in how credit protections can distort lender and financial institution practices, in ways that may not be ideal from a public resources perspective. Nevertheless, the incremental effect of credit enhancements for prospective buyers tends to be small, particularly in equilibrium (Jaffee & Quigley, 2009).

2.3.7 Summary

Sustainability is adopted by the construction sector in the form of the theory of ecological reconstruction, but in recent times, there is great emphasis on sustainable housing. This is because housing provides personal space for the individual, the place with which the occupant identifies basic urban existence. Implementation of sustainable development in low-income communities requires providing residents with affordable homes that are resource efficient, healthy and comfortable.

The analysis of sustainable evaluation tools gives a better overview on sustainability in housing construction processes around the world. Nonetheless, the consensus among the authors in sustainability related research is lack of tools that can be used globally, as the tools are developed with different criteria based on conditions to suit the characteristics of the countries where the tool is designed. Besides the lack of agreement on the framework for evaluation, the existing environmental building assessment methods have their limitations, which reduce their effectiveness and usefulness, as examined in this section. There is a requirement for greater communication, interaction and recognition between members of the design team and various agencies in the affordable housing construction market, to promote the popularity of building assessment methods. Extant literature has pointed to debates on construction methods and housing financing methods as a panacea towards achieving sustainable construction in affordable housing. The conceptualisation of the framework presented in the next chapter of this thesis will attempt to bridge the gap in literature and to transfer knowledge from the research community to construction professionals within government and the private sector, to ease the implementation of sustainable housing construction in the long run. To meet the holistic conditions of sustainability, it is crucial to implement a platform of multiple housing development management systems, such as those focused on construction methods, housing financing concepts and social integration, into an integrated system of sustainability in construction works.

CHAPTER THREE
THEORETICAL AND CONCEPTUAL FRAMEWORK FOR SUSTAINABLE AFFORDABLE HOUSING CONSTRUCTION

3.1 INTRODUCTION

The previous chapters have provided a basis for sustainable development and benchmark some guiding principles on sustainable construction. Thus, this chapter is set out to provide a theoretical perspective of the sustainability theory and theories on affordable housing development. These theories were related to approaches on affordable housing provision to develop an alternative concept upon which strategies to enhance sustainability in affordable housing could be achieved.

3.2 THEORETICAL VIEWPOINT ON SUSTAINABILITY IN HOUSING CONSTRUCTION

3.2.1 Sustainability theory

Sustainability is a measure of how the growth, maintenance or degradation of a resource or set of resources affects the abilities of a population to sustain itself. A resource can be natural or human, and includes knowledge, technical, financial and other social systems. Many theorists believe that natural resources are limited and cannot support the world's projected population at current levels of resource exploitation and growth. Due to the increase in knowledge and human capability over time, Taylor (1993), cited in Russell (1994:1), believes resources have actually increased. Sustainability then involves sustaining free markets and human knowledge capacities, since the threats to sustainability comes mainly from overpopulation and consumption on one hand, and bad policies on the other (Russell, 1994:1).

In the past, the sustainability of human society was not really at stake: the glacial change of its environment left plenty of time for adaptive response and evasion. Threats to sustainability of a system require urgent attention if their rate of change begins to approach the speed with which the system can adequately respond. As the rate of change overwhelms this ability to respond, the system loses its viability and sustainability. Both of these factors now threaten the sustainability of humankind: the dynamics of its technology, economy and population and social rates of change, while growing structural inertia, reduces the ability to respond in time.

According to Jenkins (1999), models of sustainability are sometimes divided into “strong” and “weak” approaches. “Strong sustainability” gives priority to the preservation of environmental goods, like the existence of species or the functioning of particular ecosystems. A “weak sustainability” disregards specific obligations to sustain any particular good, espousing only a general principle to leave future generations no worse off than we are. In terms of protecting old-growth forests, for example, a strong view might argue for protection, even if it requires development that would increase opportunities for future generations. A weak view would take into account the various benefits old-growth forests provide, and would then attempt to measure the future value of those benefits against the values created by development. The two views loosely correspond to eco-centric (ecologically centred) and anthropocentric (human-centred) positions in environmental ethics. The eco-centric view requires that moral decisions take into account the good of ecological integrity for its own sake, as opposed to exclusively considering human interests. But a strong sustainability view could be held from a human centred perspective by arguing that human systems depend on rich biodiversity or that human dignity requires access to natural resources.

Conversely, Barry (1997) argues that preservation of some opportunities for future generations requires the enduring existence of particular environmental goods, which could be regarded as third approach (middle view). For example, the opportunity to decide whether old-growth forests are required for a decent human life depends on their preserved existence. In another pragmatic approach, the philosopher Hans Jonas opines that powers of human agency are able to comprehensively threaten their own conditions, hence the need for renewed moral imperative to act responsibly for the sake of human survival. Perhaps sustainability is neither a strong question about nature’s intrinsic value nor a weak one about producing opportunities, but rather a pragmatic question about keeping our species in existence (Jonas, 1984). Sustainability is then a question about maintaining a decent life. It is evident from the aforementioned that theories of sustainability have become too complex to organize with dualistic terms like “strong” and “weak” or “eco-centric” and “anthropocentric’’. Instead, focus should be in terms of models for sustainability, each prioritizing its own component of what must be sustained. These models; economic, ecological and political, are not mutually exclusive and often integrate complementary strengths of the others (Jenkins, 1999; Bassiago, 1999:7). Distinguishing them, however, helps make sense of alternative concepts of sustainability. It is on this premise that this study tends to consider sustainability in affordable housing construction from the perspective of construction methods, social indicators influencing construction projects, and modes of financing to ensure economic sustainability.

3.2.1.1 Economic Sustainability theory

According To Russell (1994:5) and Basiago (1999:6), economic sustainability implies the ability of a population to generate revenue to maintain itself in a market economy and produce a surplus to invest in security, infrastructure and social safety nets. At the local level, it is the ability to maintain food and income security so as not to deplete the resource base and drive away young people. Balancing investments in government and community level activity, public and private sectors, and gauging growth potential in relation to environmental and equity concerns, is part of the sustainable development process

Economic models propose to sustain opportunity, usually in the form of capital. According to the classic definition formulated by the economist Robert Solow, *"we should think of sustainability as an investment problem, in which we must use returns from the use of natural resources to create new opportunities of equal or greater value"*. Social spending on the poor or on environmental protection, while perhaps justifiable on other grounds, takes away from this investment and so competes with a commitment to sustainability. With another view of capital, however, the economic model might look different. If it is not presumed that "natural capital" is always interchangeable with financial capital, Daly (1990), and other proponents of ecological economics, argue that sustaining opportunity for the future requires strong conservation measures to preserve ecological goods and to keep economies operating in respect of natural limits. These considerations complement a perspective of the relation between opportunity and capital, spending on the poor that might be regarded as investment in the future. However, in the political model of sustainability, sustaining opportunity for the future requires investing in individual dignity today. Russell (1994:5) and Basiago (1999:6) believed that economic growth would bring the technological capacity to replenish natural resources destroyed in the production process.

3.2.1.2 Environmental sustainability theory

Environmental models' purpose is to sustain biological diversity and ecological integrity. That is, rather than focusing on opportunity or capital as the key unit of sustainability, they focus directly on the health of the living world (Rolson, 1994 cited in Brandon & Lombardi, 2011). Within this model, there are two major ways of deciding which ecological goods to sustain. From an anthropocentric (human) point of view, essential natural resources should be sustained, as should those ecological systems and regenerative processes on which human systems rely. From an eco-centric (environmental) point of view, natural resources should be sustained for their intrinsic value, as should ecological systems as generators of creatures with intrinsic value. In policy, as noted above, strong and weak views may converge.

3.2.1.3 Social sustainability theory

Social sustainability models are concerned with the way in which local and global environmental problems jeopardize human dignity. These models focus on sustaining the environmental conditions of a fully human life. Environmental justice and civic environmentalism represent one strategy of the social model by focusing on environmentally mediated threats to human life through environmental management schemes. Other strategies within this model, such as agrarianism or deep ecology, involve more substantive visions of the human good. Plumwood (2002) and Wirzba (2003) models recommend sustaining the cultural conditions needed to realize ecological personhood, civic identity and personal faith. In this view, sustaining a social system of premeditated democracy effectively requires sustaining ecological and economic goods along with political goods like procedural rights.

3.2.2 Theoretical perspective on Housing

The theory of housing has its origin in the Palaeolithic period, when homo-sapiens began to use natural materials like stone, wood, leaves, animal skin and other similar items to create shelter. However, the motivating factor for housing was fortification from external aggression and from climatic elements like sun, rain, heat, cold and other extreme weather conditions. Due to this, it is imperative to have an understanding of the theoretical basis upon which affordable housing planning and development is predicated in the extant literatures. Housing theory has evolved in the literature since the mid 1960s, although authors such as Pugh (2000) and Van Vliet (2003) have argued that housing concepts cannot be precisely fit into a single theoretical framework. Sullivan and Gibb (2006) viewed housing as an inherently multifaceted commodity with defining characteristics; as an asset and investment with consumption dimensions to account for. To Lux (2003), housing is not a commodity that can be viewed from a single perspective. Though, it is one of the basic human needs, and the right to adequate housing has been classified as a basic social human right in both developed and developing countries. Lux (2003) further argues that housing constitutes a special type of private property traded on the market in which social and economic decisions on it have to be made for all social groups within a society. However, housing research draws from a number of disciplines and professions, including; economics, geography, planning science, architecture, construction management, etc. (Van Vliet, 2003). The author further states that respective disciplines tend to direct the focus of their research towards a specific hypothesis that characterises the discipline more generally. For example, disciplines such as architecture, construction management and building emphasise on design of housing, building materials, construction techniques and housing finance. Although, this emphasis of attention is not mutually exclusive nor exhaustive. It is noteworthy to state that this study draws contributions from a wide range of housing studies to delineate the subject matter.

Housing in today's context has become a multi-dimensional service, comprising the need for privacy, aesthetic value and conformity to statutory standards, fiscal economy and other related issues of importance in contemporary society. Fundamentally, housing has been perceived as a refuge for emotional and physical rest, and the stability found therein empowers families in their pursuit of a better quality of life. Adequate housing enhances healthy living, learning and academic accomplishment. Nonetheless, housing is one of the most important elements in life, it is both a shelter and link to the neighbourhood and larger community. Housing also refers to both the product and the process of its attainment. When housing is misunderstood and treated as a commodity serving the interests of commercial or political manipulators, attention is focused on the end products and diverted from the ways and means by which homes and neighbourhoods are planned, built and maintained (Turner, 1980:204). Housing is greatly perceived according to its performance, and its usefulness varies with the level of comfort and operational cost required of the occupant. The full benefit of housing is recognised by the people when they come to live in it and it is acceptable to the community and its operations meet their financial capabilities (Turner, 1980:204), which is the concern of this research. Thus, the next section provides an overview of three approaches to housing; the Turner's theory, economic theory and social theory.

3.2.2.1 Turner's theory on provision of affordable housing

John F.C. Turner's ideas came as a response to the general failure of the public sector's housing provision in most third world countries. Turner sited the origins of the housing problem in third world countries in the operation of a bureaucratically and technologically top-bottom approach. Housing is understood as an activity, as a complex process of many people and organisations doing many things in order to get many kinds of expected or unexpected results. The product of the housing sector is seen as a 'social overhead cost' which is dependent on 'directly productive activities' and on the political, economic and industrial organisation of society (Turner, 1980:203). Furthermore, Turner advocated a number of concepts for affordable housing development, which are of importance to this study. The first among this concepts is “dweller control”. According to Turner, any housing programme is capable of successfully delivering, provided it permits prospective owners to make basic decisions about their own housing environment. This will free such housing programmes from the bureaucratic top-bottom approach that characterised government low-income housing projects.

To complement dweller control, Turner suggests freedom to build. This assertion is reinforced with the argument that the best results are obtained by a user who is in full control of the design, construction and management of his/her own house, while it is of secondary importance whether or not the owner personally builds with his/her own hands (sweat equity), unless the house owner is very poor (Harris, 2003:248). According to Turner, when beneficiaries are able to make major decisions about the construction process of their houses, they will construct dwellings of types and qualities corresponding to their economic capacity, social circumstances and cultural habits. Turner (1976) further reiterates that government’s role within the autonomous system is to provide those aspects of housing that people are not always able to provide for themselves, such as land, enabling laws, tools, credit, know-how and skills, instead of dictating terms and conditions for people willing to build their own house. Since housing, as an activity, involves everyone and much of people’s time and savings, is a large part of industry and occupies most urban land, housing is obviously an instrument and vehicle for change and it influences change in other spheres of the economy. Turner advocates “housing by people”, and his argument is that housing by the masses denotes that there is active participation by beneficiaries, and that it is much more viable than mass housing in which the government owns and controls the construction process in its entirety (Pugh, 2000:327).

Central to Turner’s theory is the ‘housing as a process’ and ‘progressive development’ concepts (Pugh, 2000:327 and Harris, 2003). Turner regards a shack as a house in progress and states that a shack will be upgraded to a house provided an enabling environment is created and the family finances permit. However, the key issues here are; creation of an enabling environment that embraces the use of local resources and skills in housing delivery, and tasking the state to provide the service infrastructure that will enable and stimulate local housing provision (Stein, 1991). Summarily, Turner’s emphasis is on the need to promote housing delivery that will accommodate the financial circumstances of the dwellers, while government plays a supervisory role.

3.2.2.2 Housing economic theory

Economic theory on housing draws its guidance from Neo-classical economics that became prominent in the late nineteenth century. Brennan and Moehler (2010) explain that neo-classical economics rely on subjective preferences for determining prices, instead of using the objective value theory of classical economics to which the value of goods could be established by reference to some basic commodity or the labour input required to produce goods. However, neo-classical economics in its study of the economy makes four suppositions. First, they opine that the creation of goods and services reveals the preferences of consumers. Second, neo-classical economics assumed that all households and organisations have perfect information. Thirdly, households get the most out of utility and organisations maximise profit because of the existence of perfect information. Lastly, the creation of goods and services is assumed to be flexible in that the factors of production can easily be interchanged. It is to be noted that the theoretical roots of these suppositions are underpinned in 'methodological individualism', which is the methodological position that explains all economic phenomena in terms of the characteristics and behaviours of individuals.

Further to neo-classical economics suppositions, authors Kain (1962), Alonso (1964) and Mills (1972) propose an adjustment model for residential location. The adjustment model suggests an association between the consumption of housing space and travel costs. The underlining assumption is that a household's travel costs increase away from the city centre as opposed to housing cost, which decreases in attempt to maximise utility subject to overall budget constraint. Nonetheless, Li (2002) reports that the relationship between transport cost, housing cost and income and other trade-offs are joined together in the adjustment model to predict the relationship of individual households and those of different income groups. Mills' (1972) model of urban structure predicts the decline of land value and population density from the city centre. Thus, individuals will always trade-off one commodity for another. According to Truett and Truett (1987), housing constitutes a heterogeneous, multifaceted and multidimensional good. This is because individual houses differ in floor space, design, quality, location, quality of the environment and accessibility, amongst others. Lux (2003) noted that these expressions have necessitated housing economists to introduce a theoretical construct referred to as 'housing service'. Housing service, according to Lux (2003), states that *"in a state of equilibrium, the price per housing service unit will be the same in all types of dwelling units"*. Lux (2003) argues that housing consumption and investment motives may conflict, in the sense that the consumer goal is to maximise utility while the investor goal is to maximise net present value of expected future returns. Conversely, sufficiency of housing is dependent on investments from both the government and private developers, as the investments will stimulate a vibrant urban system and contribute to urban competitiveness (Monk & Whitehead, 2010).

Consequent upon the aforementioned, the economic perspective of housing has shown that benefits such as employment creation accrues from investment in housing. In reality, housing wealth can be converted into additional income and, as a result, alleviate poverty among home-owners. Monk and Whitehead (2010) further inform that lack of adequate investment in housing leads to market inequality and social exclusion. However, the poverty reducing effect of being a home-owner diminished significantly as the home-ownership rate increased. The impact of housing on a family includes the opportunity that living in better housing could lead to better economic position of the household.

Conclusively, with all the over-arching economic benefits of housing, housing has not been treated in the mainstream of macro-economics. Researches on conventional housing economics have virtually ignored the relationship of saving in economic investments at the post housing construction stage. At best, some of the theoretical analyses for housing economics include macro-economic variables such as inflation, gross domestic product (GDP), unemployment rate, etc. as exogenous variables.

3.2.2.3 Housing social-cultural theory

A full conceptualisation of sustainable housing has been suggested to include access to resources for equitable distribution to meet people's environmental and socio-economic needs. Resources are valued and used within the human framework of ideas and social structures. Socio-cultural sustainability relates to the soundness, richness and flexibility of organisations and institutions that govern access to and transmission of resources (Russell, 1994).

The right to housing is a social right and it is the third element of human rights, aside political and civil rights. Right to housing is equal and non-discriminatory with respect to race, religion and gender. The social perspective of housing is mostly accepted, as the right to adequate housing which is understood as ensuring affordable housing for the disadvantaged and endangered social groups. Lux (2003) informs that the right to housing is a general awareness and acceptance of a housing price level in the society at large, that ensure the fulfilment of basic needs in the field of housing. Lux (2003) further reiterates that effort must be geared towards a continued guarantee of financial affordability of housing, especially in relation to groups of the population that cannot by themselves ensure adequate housing on the free housing market.

Supporting institutional sustainability does not mean sustaining specific institutions or organisations, however, but helping people to build and strengthen legislative frameworks and financial regulations that allow sound institutions to flourish.

3.2.3 Summary

Sustainable development scenarios must be broken down into levels and objectives, and then pieced back together again. The larger objectives of increasing productivity and equity and reducing stress need to be brought to the activity level. The process of increasing sustainability benefits must be tied to the larger process of conceptualizing sustainable development flows and resources. This section presented a preliminary outline for that process. What is now needed is to conceptualise what aspects can realistically be implemented in what period.

3.3 THE STUDY CONCEPTUAL MODEL

Development of strategies to enhance sustainability in housing requires in-depth evaluation of existing sustainability assessment tools. This, however, allows the subject to progress and encourages building up of knowledge to develop in a coherent and systematic way. This is the objective of this section, to describe the concepts employed in this research and to make known the position of the researcher with respect to current discussions in affordable housing construction and sustainability in general. Going forward, a conceptual model was developed to proffer solutions to the issues relating to the environment, economic and socio-cultural requirements towards enhancing sustainability in affordable housing for the poor population.

Enhancing sustainability in affordable housing has a strong correlation to the ‘triple legged’ stand of sustainability. Although previous studies have shown correlation between economic growth (consumer’s income), the level of urbanisation, the quality of shelter and basic services provided, and social indicators, there is a need for a strong supportive institutional (policy) framework, including a wide range of inputs and expertise to deal with all different aspects. The roleplayers involved and their actions at various levels should accelerate and integrate the process of development in a way to achieve robust sustainable development. However, existence of relevant regulations not appropriately implemented and inefficient planning systems can disrupt housing supply for the poor majority. An uncompromising policy framework is therefore essential for the efficient working of the policy, which can optimise the limited resources and integrate the various stakeholders. It is important to drive provision of housing based on user's demand, rather than it being an imposition by the authorities.

This conceptual framework for affordable housing construction in Figure 3.1 is a combination of sustainable construction practice parameters and economic (with emphasis on economic aspects of building construction and its operation) criteria. The sustainable construction practices, as shown in Figure 3.1, comprises of environmental sustainability criteria for selection and management of building construction methods (as it affects building design, building materials selection and construction waste management practices). While, the social sustainability criteria comprise of stakeholders' engagements in planning and construction of affordable housing and infrastructural development. These constructs are referred to as "constructs for affordable sustainable construction environment (CASCev) and "constructs for affordable sustainable construction social" (CASCso) in this thesis. The sustainability economic criteria comprises of housing financing methods. This is tagged "constructs for affordable sustainable construction economic" (CASCec).

Integrating the sustainability criteria identified under the proposed constructs (CSACev, CSACso and CSACec) is intended to assist in formulating strategies for affordable housing construction towards enhancing sustainability. The development of interactions between the research constructs shown in Figure 3.1 and Figure 3.2 further illustrates the process through which the research objectives are achieved.

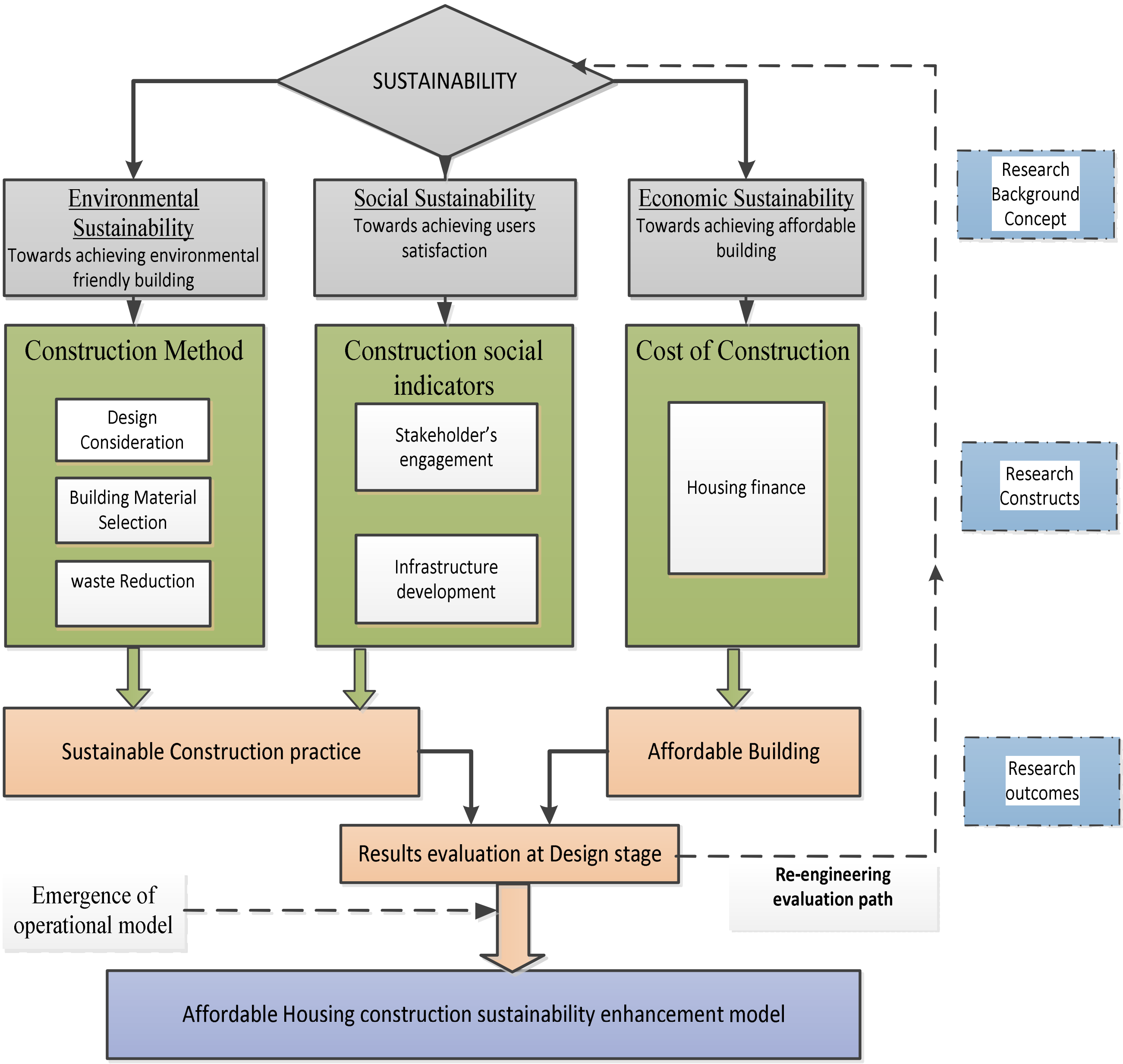

Figure 3. 1: The study conceptual framework

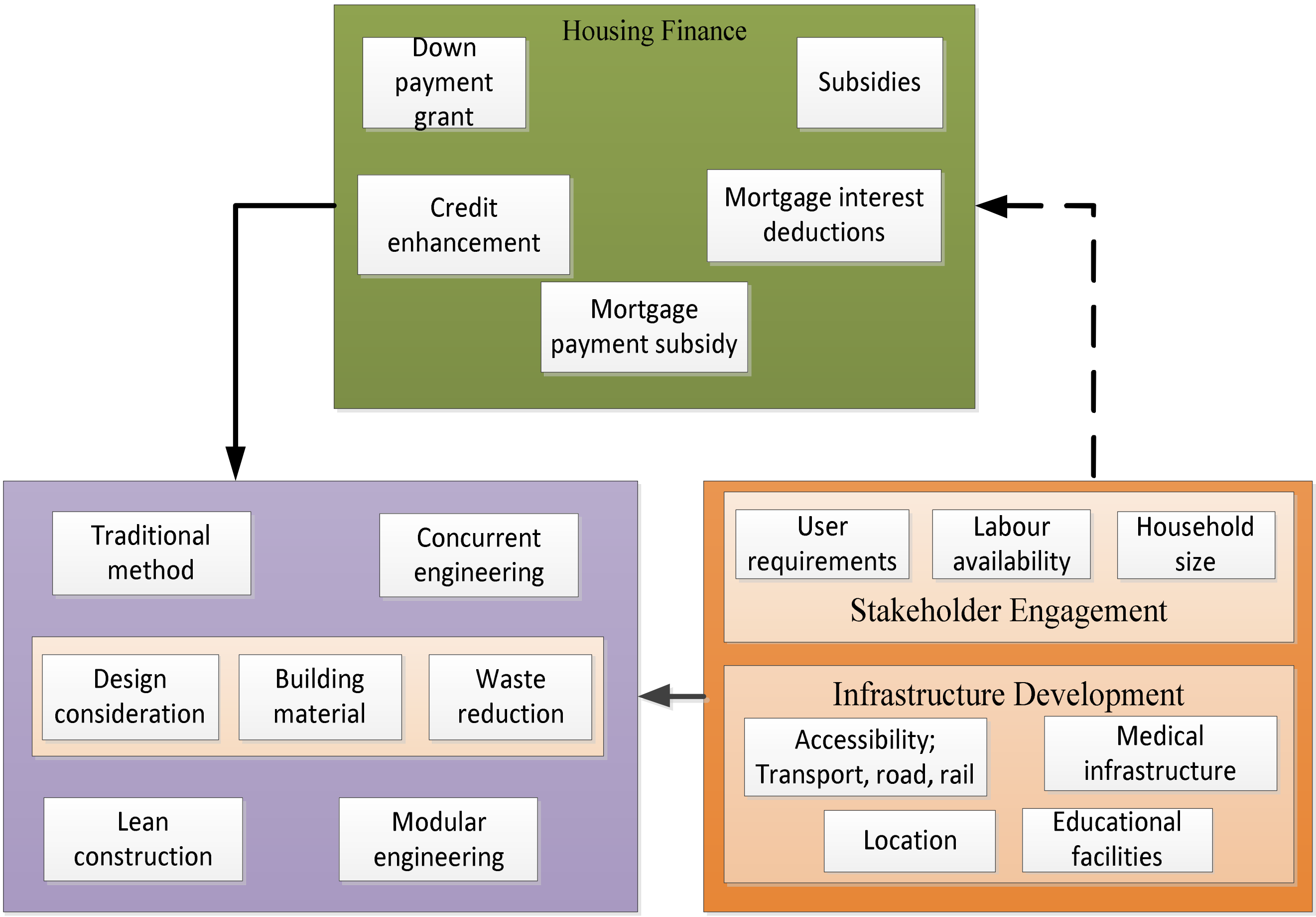

Figure 3. 2: Interface between the research constructs

Figure 3.2 illustrates the indicators to enhance sustainability in construction of housing within the tripod bottom-line of sustainability. The sustainability enhancement in construction works conceptual model in Figure 3.1 and Figure 3.2 is a departure from the concept proposed by Ding (2004), Nair (2006) and Akadiri (2011). This framework considers the mode of housing financing, which is inherent to the economic capabilities of occupants of the building, stakeholder influences and demands for basic infrastructures, which are linked to social sustainability indicators, and construction methods which are inherent to the consumption of natural resources as materials for construction purposes. The model optimizes the sustainability objectives and targets of a client, the specific conditions of an actual project and the particular site of the project. The model was developed with the goal of structuring different sustainability aspects on housing construction, in order to evaluate the development of new and existing building works based on the requirements and needs of stakeholders.

3.3.1 Construction Financing as a Factor of Housing Sustainability

Financing and funding of sustainable construction and refurbishment has been identified as a major problem for housing development or refurbishment activities (Lorenz, Lützkendorf & Panek, 2005; Tomlinson, 2007). This assertion helps to identify the significance of a viable financing mechanism for a housing construction project, in order to enable the poor majority to have access to sustainable means of financing a housing project. There has been lots of debate on the role of government in subsidising housing construction and the role of mortgages in financing housing, but a common concern is on the best form of aid to low-income, first time home owners. In addition, Persson (2009) opines that there are significant opportunities for both financial institutions and business activities to implement measures within lending procedures that support sustainable development in the housing and construction sector. There is a definite need to look for economic indicators that address monetary flows related to the life cycle economy of the building(s) as an investment, such as; usage of buildings, maintenance and repair, deconstruction and waste treatment, development of economic value of the building, and revenue generated by the building and its service.

3.3.2 Social Sustainability Indicator in Construction of Affordable housing

Persson’s (2009:104) work helps to explain the significance of identifying stakeholders and their claims on the project. Project stakeholders are individuals and organisations who are actively involved in a project, or whose interests are affected by the execution of a project or by a successful project (Olander, 2006). A stakeholder could be any individual or group with the power to be a threat or a benefit to the project (Gibson, 2000). According to Persson (2009) when identifying stakeholders, it is not enough to focus on formal structures of project organisation. It is essential to have a look at informal and indirect relationships between stakeholder groups and to assess their importance and to identify the relative power different stakeholders have on the implementation of a project (Johnson & Scholes 1999). According to Drouet (2003), some stakeholders can provide economic instruments to promote sustainability in construction works.

Lützkendorf and Lorenz (2005) and Person (2009:67) posit that social indicators should be used for describing the interface between the building and sustainability issues at the community level, based on criteria such as quality of the building as a workable and liveable place, building related issues of health and safety, access to services, user satisfaction, cultural protection and design quality. The indicators also include the possibility for social cohesion, such as a mix of social and cultural groups and use of local labour during construction. Therefore, the social aspects of the project must be fully considered and integrated into decision-making (Mahi, 2001). However, concerning the social aspects, information between the stakeholders in a construction project is one essential missing part, especially regarding complex relationships and interactions related to sustainability issues.

The uniqueness of construction works are of two kinds: the product and the site where the building is situated. The site or the location of use of a building is a key variable of design and management decisions (Moffat & Kohler, 2008). Where the actual building addresses aspects such as energy use, indoor climate and material productivity; the site of a building addresses aspects such as accessibility to neighbourhood buildings, security and local biodiversity, transportation systems, air quality, public health and emergency preparedness. Thus this research considers the social sustainability attributes that have been identified by Moffat and Kohler (2008); Lützkendorf and Lorenz (2005) and Person (2009:67) as the indicators upon which user satisfaction could be achieved in affordable housing construction projects.

3.3.3 Construction Methods as Sustainability Enabler

According to Robichand and Anantatmula (2011), sustainable building projects are inherently different from conventional building construction from the technical point of view. It is subsequent upon this that the conceptual model covers the technology enablers of sustainable construction works mentioned in Chapter Two of this thesis. According to du Plessis (2007), the technology enablers consist of hard technology (e.g. equipment, material and processes), soft technology (e.g. systems or models that support decisions, assessments and evaluations), knowledge and information. Abidin, et al. (2013) assert that sustainable buildings will cost about 5% - 10% more due to the hard costs of purchasing new technologies, therefore, the fear of upfront cost has been ascribed to ignoring the implementation of sustainable design and technology in the construction industry (Sonagar & Fieldson, 2008). While hard technology increases cost, soft technologies enhance the construction process by using suitable systems and tools that support decision-making, monitoring and evaluation of construction activities (Lapinski, Horman & Riley, 2006). On the other hand, Abidin, *et al.,* (2013) argued that a significant portion of the additional costs of sustainable building is on the soft costs of design, certification, modelling and consulting.

To carry out the process of construction towards sustainability, it is thus vital to focus on how to make technology (hard and soft) easily accessible and available at the cost level affordable to the stakeholders. There is also a need for re-evaluating the value systems to motivate people to act towards sustainability by adopting sustainable construction methods in building projects (du Plessis, 2007). It is against this backdrop that this study considers the assertion of notable authors such as Deshpande, *et al*., (2012) and Bashford, *et al.,* (2005), who advocate lean construction techniques for residential building construction. In addition, authors notably (De La Garza, *et al.,* 1994; Baxendale, *et al.*, 1996; Evbuomwan, & Anumba, 1996; Houvilla, *et al.,* 1997; Love *et al.,* 1998 and Kamara, 1999) have considered Concurrent Engineering appropriate for sustainable housing construction based on the benefits of CE towards enhancing sustainability in construction. While Badir and Kadir (2002) and Ahadzie, *et al.,* (2008) posit the Modular construction method, due to simplicity of assemblage and faster production rate, amongst other benefits.

3.4 Critique of Sustainability Assessment Tools in Construction Industry

Building sustainability assessment methods contribute significantly to the understanding of the relationship between buildings, the environment as well as the occupant. There are a lot of useful tools, commercially available or under development, for construction works regarding the evaluation of sustainability assessment. Most of these focused on environmental assessment and economic evaluation. Assessment tools developed so far were merely aimed at building-related aspects (Jensen & Gram-Hanssen, 2008). The focus of assessment tools developed in this study is to integrate stakeholders and construction financing methods into the construction process, and to disseminate the new practices and processes into the affordable housing sector. To corroborate the above, Lützkendorf and Lorenz (2005) opine that a sustainability assessment model that captures the requirements of different users (construction professionals and households) is desirous by the construction industry; hence, the necessity for a structural model that combines sustainable criteria into a composite model for implementing construction of affordable housing. This section presents very briefly some examples of different tools and the limitations that hamper their usefulness and effectiveness.

3.4.1 Environmental impact assessment tools

Environmental impact assessment tools are divided into Life-Cycle Analysis (LCA) or Criteria-Based Tools or a combination of the two. In spite of LCA's powerful time stretching accounting approach, LCA is not well integrated into construction management, because of the limit of location variables (Moffatt & Kholer, 2008). The building site, which is a key variable of design and management decisions (e.g. the indoor environment of users that implicates aspects such as productivity, health, comfort and safety) could not be assessed using LCA.

Environmental building assessment methods are most useful during the design stage when any impairment for the pre-design criteria may be assessed and incorporated at the final stage of design development (Ding, 2004). Edwards and Bennett (2003) present some LCA-based tools mainly for the design stage of a construction project. Boonstra and Pettersen (2003) mention a couple of criteria-based tools intended for existing buildings from various countries, and tools that are a combination of LCA and criteria based (SBIS, 2008) are shown in Table 3.1.

Table 3. 1 Combination of criteria- and LCA-based assessment tools (adapted from SBIS, 2008)

	Tools	**Country**
1	GBTool	International
2	LEED, SpiRiT	USA
3	Equer	France
4	BREEAM	UK
5	OGIP	Switzerland
6	H-K BEAM	Hong Kong

A more general instrument for determining the environmental impact of materials, ‘ecological rucksack’, is mentioned by Wallbaum and Buerkin (2003). With this rucksack as input, it is possible to estimate resource productivity with the method of MIPS, a monitoring tool for material flows. The ecological footprint (Rees 1999) is another method of estimating resource consumption. The footprint is expressed in the amount of land and water required to produce the resources consumed and to assimilate the waste generated by a specific population.

3.4.2 Economic tools

Evaluation of Life Cycle Costs (LCC) could be used to assess whether higher initial costs are justified or not by reductions in future costs (new building or replacement of elements in existing buildings), and if a proposed change is more cost-effective than the do-nothing alternative (Clift, 2003). LCC usually consists of initial capital costs, managing and operating costs, costs for maintenance and renovation, and costs of deconstruction (Lützkendorf & Lorenz, 2005). LCC has become a popular way of solving sustainability issues such as recycling and demolition costs. However, Gluch and Baumann (2004) argue that LCC is not appropriate since LCC was developed to rank investment alternatives, and not to consider environmental concerns. It is important to emphasise that a traditional LCC does not become an environmental tool just because it contains the words life cycle (Gluch & Baumann, 2004:571).

Similarly, Cole and Sterner (2000) contend that the use of LCC depends on project design practice. However, the foremost role of LCC is to provide managers with a framework for decisions and the evaluation of specific choices. Total cost of ownership (TCO) considers the total life-cycle of a facility where all the facility costs are taken into account during each of the phases highlighted below (Hodges, 2005):

- Planning, design and construction: Client’s needs, Space utilization, Design and construction, and Commissioning.
- Capital asset management: Facility operation, planned maintenance, Requested maintenance, Emergency repairs, Renovations, Retrofits, Upgrades, and Improvements.

Another economic tool, often used to evaluate different investment alternatives, is cost-benefit analysis. Cost and benefits are evaluated on a variety of levels, e.g. cost-benefit analysis (CBA), and social cost-benefit analysis (SCBA) (Barrow, 1997). The most basic level is the purely financial analysis, which assesses the impacts of different alternatives on the organisation’s own financial cost and revenues. When it comes to assessing more than the purely financial impacts, a CBA or SCBA is often used, which tries to value the environmental, social and cultural impacts of different alternatives in monetary terms alongside purely economic factors. These tools are often used to assess public investments, thus attempting to evaluate the full impact of different alternatives in monetary terms. In practice, it is hardly ever realistic to value all the costs and benefits of options in monetary terms. Most cost-benefit analyses will incorporate some additional items, which are either not possible to value, or not economical to do so.

Conversely, some assessment tools such as BREEAM, BEPAC, LEED and HK-BEAM do not include economic indicators in the evaluation framework. This may contradict the ultimate principle of a sustainable development, as economic return is fundamental to all projects because a project may be environmentally sound but very expensive to build (Ding, 2004; Akadiri, 2011). Therefore, to ensure economic sustainability in a building construction project, environmental, social and economic considerations should go concurrently as part of sustainability evaluation when making decisions.

3.4.3 Social and cultural assessment

According to Barrow (1997), there are techniques and methods of social impact assessment such as social surveys, questionnaires, interviews and available statistics. The latter include census data, nutritional status data and findings from public hearings, operations research, social-cost benefit analysis, marketing and consumer information, reports from social, health, crime prevention and welfare sources, and field research by social scientists. Among these, the use of census and demographic data tends to be the easiest, and causes few challenges and problems. Environmental psychology issues of design and construction (Cassidy, 1997) point to the necessity of participation of stakeholders, especially the end-users, in the process of designing a construction project. One major aspect of the design, argues Cassidy (1997), is privacy, both the need for interaction and of not interacting. Optimization is also needed for homogeneity and heterogeneity in neighbourhoods and separation of land use into commercial and residential areas. Designers must consider better health, comfort, satisfaction, less crime and a peaceful existence as the ultimate goal of a housing project. Thus, a sustainability assessment model must have the capabilities to evaluate all of this in order to achieve a sustainable development.

3.4.4 Multi Criteria Analysis

In decisions concerning sustainability, multiple factors are involved. Popularly, Multi-Criteria Analysis (MCA) is used to establish preferences between an explicit set of building sustainability objectives that the decision maker has identified to establish measurable criteria to assess the extent to which the objectives have been achieved (Persson & Olander, 2004). In addition, the evaluation obtained through MCA does not give an optimal solution because a single criterion is not the best when all criteria required to achieve reliable evaluation of sustainable building objectives are considered. Hence, there is the need to aggregate construction criteria into a composite structural model for implementing the construction of affordable housing, which this research aims to establish.

3.5 Chapter summary

Decision making for sustainable development in the built environment requires new approaches that are able to integrate and synthesise all the dimensions of building affordable housing with other parameters in a holistic manner. From previous chapters, it is evident that much of the early work on sustainable development in the built environment focused on the environmental dimension of the problem. On the other hand, the dimension of sustainable affordable housing development (construction methods, project financing methods, social and cultural impacts) have not been addressed, while existing assessment tools do not cater for them in the assessment process.

Devising strategies for sustainability enhancement in housing development is difficult, not because the nature of affordable housing construction is complex, but because the concept is ambiguous, multi-dimensional and generally not easy to understand outside the single issue of environmental protection. Brandon and Lombardi (2011:124) suggest that effective urban sustainable development strategies can best be identified by ensuring that decision makers and building developers are adequately informed on sustainable development issues, local characteristics and community needs. This approach requires the application of a suitable operational framework and an evaluation method that is able to guide developers through the decision-making. However, at the moment, such a structure for organising the information required in decision-making is not yet available or agreed upon among the stakeholders involved in provision of affordable housing. This confirms the necessity for the structural model this research is set out to develop.

Lützkendorf and Lorenz (2005:222) added that to assess a building, it is necessary to formulate a definition of its performance that could be defined as the compliance of user/owner requirements with corresponding building characteristics and attributes, or simplified as behaviour in use. A major constraint is the lack of an established structure that helps the decision-making process achieve sustainability in housing delivered to the people. This chapter proposes an integrating framework which could bring together the diversity of interests necessary to construct an affordable housing method that is sustainable and enhances the impact of the built environment on urban sustainable development. All stakeholders in the development of a building, including policy and technical decision makers, designers and financial advisers, could use this framework to check a design in the context of sustainable construction. It should assist the process of devising sustainable planning strategies, ensuring that all sustainable development aspects and quality of life issues are included. It also provides a structure that can be used at different levels of detail, thus providing a vehicle that all stakeholders can engage in.

CHAPTER FOUR
RESEARCH METHODOLOGY

4.1 INTRODUCTION

This chapter outlines the research methodology to be adopted for undertaking this research study. When undertaking research it is important to choose the correct methodology, to ensure that the research objectives can be met and that the findings can be validated (Akadiri, 2011:169). It is on that premise that a mixed method approach, that incorporates the qualitative and quantitative approach, is proposed for this study. Arguments are presented justifying the choice of this approach and the specific research methods to be applied to collect data.

4.2 RESEARCH PHILOSOPHY

The reason behind every research is to contribute to a special field of issues with something unknown, unpredictable, or interdependent to the body of knowledge (Tan, 2002). The specific purpose of a research study is to investigate problem(s) systematically and thoroughly, aiming to describe, predict, explain or interpret phenomena. However to achieve this contribution, it is essential to approach the research in a systematic way with appropriate and scientifically approved methods (Atkin & Wing, 2007:1). Atkin and Wing (2007:1) further reiterate that;

> *"Knowing which path to follow, which tools and techniques to apply, and how to make sense of findings are the fundamental prerequisites of good research and, likewise, good researchers."*

The terms 'methodology' and 'methods' could be seen as related concepts, but they both have different connotations. The term 'methods' of a research are the actual techniques or procedures used to gather and analyse data related to research questions and hypothesis (Easterby-Smith, *et al.,* 2012:18). This includes techniques such as getting participants to fill out questionnaires, engaging people in discussions, document analysis and observing behaviour. Thus, 'methodology' is defined as a particular procedure or set of procedures on how research should proceed (Creswell, 2011). According to Creswell (2011), methodology addresses three important questions:

- What knowledge claims are being made by the researcher?
- What strategies of inquiry will inform the procedures?
- What methods of data collection and analysis will be used?

Therefore, methodology does not simply connote a set of methods, rather general philosophies of science and detailed research methods (Saunders, *et al.,* 2009; Creswell, 2011; Easterby-Smith, *et al.,* 2012:18).

The philosophy underpinning a research involves thinking about the questions, making interpretations, drawing inferences, formulating ideas and thinking of possible arguments for and against them, and wondering how the concepts work in reality. According to Easterby-Smith, *et al.,* (2012:17), the three importances of understanding the philosophical issue of a research are: it helps to clarify research designs; knowledge of philosophy helps the researcher to recognise which design will work and which will not; and it helps the researcher identify and create designs that may be outside the researcher's past experience. Easterby-Smith, *et al.,* (2012:17) further state that research philosophy may also suggest how to adapt research design according to the constraints of different subjects or knowledge structures. This is summarised in Figure 4.1.

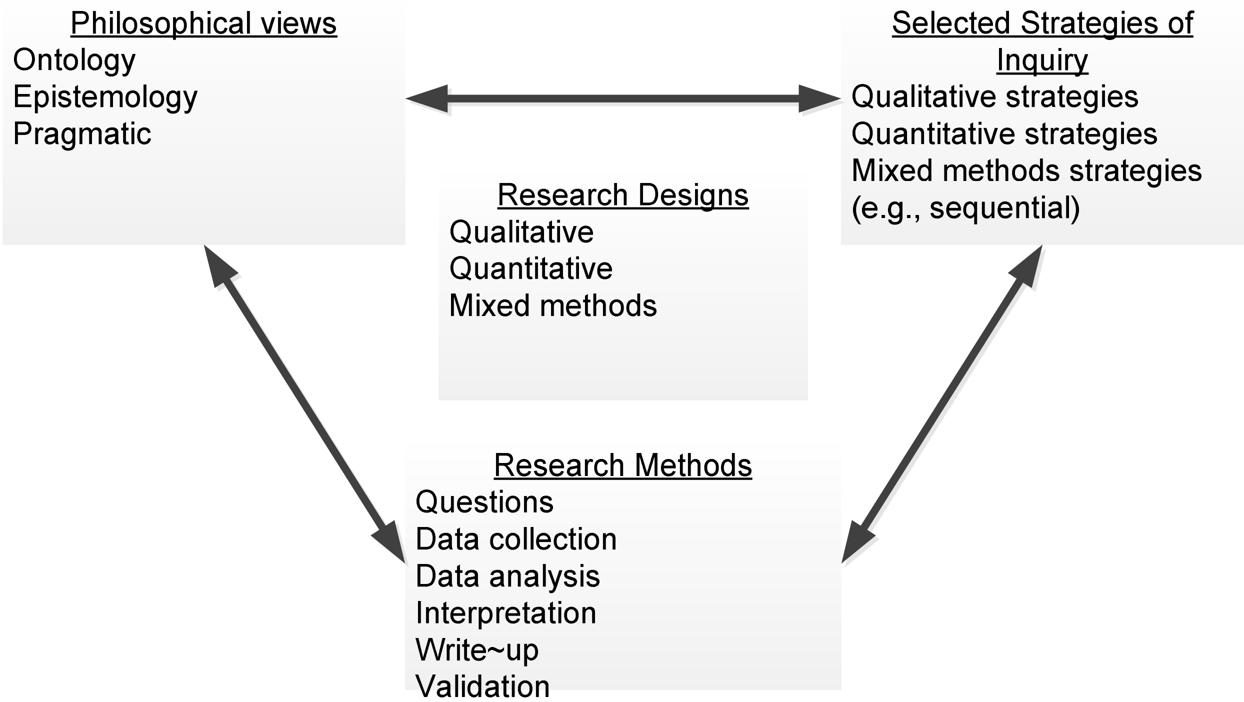

Figure 4 1: the interaction of philosophical views, research strategies and methods

When carrying out research on sustainability and housing construction within social science research and by extension the construction management research community, the two main philosophical schools of thought are ontology and epistemology (Easterby-Smith, *et al*., 2012:18), though insight into a pragmatic philosophical stance is also discussed in the section 4.2.3.

Greener (2011:4) opines that having knowledge of philosophy of social research will boost the probability of a researcher making suitable method choices. This corroborates the assertion of Denzin and Lincoln (2000:9) that choice of paradigm by a researcher provides the philosophical guidance and assumptions upon which research is based. It is important to understand the philosophical underpinning of the research paradigm employed in the study so that disparity in research approaches and nature are eliminated. This is achieved through consideration of issues of ontology and epistemology and research paradigm under each of the philosophical positions.

4.2.1 Ontological Consideration

Ontology involves investigation to elucidate the reality and existence of facts about the subject of research (Easterby-Smith, *et al*., 2012:17). In other words, it revolves around the question of "what is" and why things happen the way they do. According to Greener (2011:6) ontology is consider when a researcher thinks the guiding theory about an investigation to be conducted exists independently of the researcher's perception. Scholars such as Fitzgerald and Howcroft (1998:323) and Easterby-Smith, *et al.,* (2012:19) highlighted two broad ontological paradigms as realism and relativism.

4.2.1.1 Realism

Realism as an approach aims to understand the reality of the social world in its natural state. At ontological level, the realist position views the external world as hard and tangible structures that prelude independent of an individual's ability to acquire knowledge about them. The realist position is practical and not concerned with abstract or idealistic views of life.

Realists believe that a researcher may not be able to change or understand the world socially until the underlying structures that create the natural event or conversation is identified (Stiles, 2003:265; Carisson, 2005). Though, realists argue that the knowledge may be incomplete or biased, but it is vital to offer an explanation on reflections from the social world using hypothetical structures to ascertain the fundamental mechanism that affects people's actions or behaviour (Stiles, 2003:265). Many schools of thoughts of realism exist in literatures, but there is no unified realism theory, though a common ground exists among the realist types (Ponterotto, 2005:129). Adopting a realist approach in all areas of endeavour accedes some underlying assumptions, some of which is listed below, as extracted by Ponterotto (2005:130):

a). All thought is fundamentally mediated by power relations that are socially and historically constituted.

b). Facts can never be isolated from the domain of values or removed from some form of ideological inscription.

c). Language is central to the formation of subjectivity.

d). Certain groups in society are privileged over others.

e). Oppression has many faces and focusing on one at the expense of others often omits the interconnections among them.

f). Mainstream research practices are generally implicated in the reproduction of systems of class, race, and gender oppression.

Stiles (2003:265) maintains that the realist methodological approach inclines towards mixed methods, since the approach has reliance for semi-structured interviews or group observation to collect rich subjective data. This is further strengthened by the inclusion of deductive methods and theoretical framework emanating from literatures. The data is then analysed through the process of triangulation, thus making realism an element of unification by offering a philosophical bridge between positivist and the phenomenologist position (Stiles, 2003:265). However, the aforementioned has shown that the realist perspective incorporates both the social environment and its underlying structures, since it approaches the investigation from the perspective of both subject and object, and reflects both inductive and deductive qualities of a particular phenomenon.

4.2.1.2 Relativism

Relativism arose from dissatisfaction with some aspects of the realist view. Relativists perceive reality as being directed by socially transmitted terms and varies according to language and culture, such that concepts such as right or wrong, truth and falsehood could differ from culture to culture and situation to situation (Fitzgerald & Howcroft, 1998:321). However, the relativist position holds that human intellectual mechanisms are flawed and that life’s phenomena are basically intractable and therefore “true” reality can never be captured.

The key distinction between the realist and relativist views is that the realist stresses “theory verification” while the relativist stresses “theory falsification” (Lincoln, & Guba, 2000:107). Despite the distinction between the two ontological positions, they share much in common, as both provide an explanation that leads to prediction and control of phenomenon. However, both the realist and relativist operate from both nomothetic and etic perspective. Realism and relativism serve as the primary foundation and anchor for qualitative research.

4.2.2 Epistemological Consideration

Epistemology is the branch of philosophy that studies the nature of knowledge, in particular its foundation, scope and validity. Epistemological consideration deals with questions of knowledge acceptability in a discipline, and is concerned with the "how we know" and the methods through which knowledge is acquired (Bryman, 2012; Easterby-Smith, *et al., 2012:22*). Scholars notably (Love, *et al.,* 2002:295; Bryman, 2012), have grouped the epistemological position broadly as "positivist" or "Interpretivist".

4.2.2.1 Positivism

Positivism is a form of philosophical realism adhering closely to the hypothetical deductive method (Ponterotto, 2005:128; Fellows & Liu, 2008:17). Positivists adopt the stance that a researcher will operate remotely from the social world, and evaluation of phenomena identified will be approached through objective methodologies (Stiles, 2003:264). Positivism focuses on efforts to verify prior hypotheses that are most often stated in quantitative propositions. This branch of philosophy is traceable to the nineteenth century which is often referred to as the modernist era, with specific origin rooted in Mill's 1843/1906.

A positivist prefers exact measures and objective research whereby hypotheses are tested to discern the facts and relationships that can be generalised to the population, which includes behaviourism and empiricism. According to Stiles (2003:264), positivism stems from epistemological assumptions of a belief in an external reality constituted of facts that are structured in a law-like manner. Easterby-Smith, *et al*., (2012) view positivism as a school of thought that is grounded upon the idea that the social settings exist externally and that its behaviour is measured objectively, rather than drawing subjective interface through feeling, thinking or instinct.

Positivism favours the quantitative approach, which mostly uses questionnaires for data collection, experiments, surveys and analytical statistical analysis (Neuman, 1997; Stiles, 2003:264).

4.2.2.2 Constructivism – Interpretivism

The constructivist paradigm is perceived as an alternative to the positivist paradigm. Constructivism's stance can be traced back to Kant's (1881/1966) Critique of Pure Reason. Hamilton (1994:63) expresses Kant's position as "human perception derived not only from evidence of the sense but also from the mental apparatus that serves to organise the incoming sense impressions" and that human claims about nature cannot be separated from what they know about the subject.

Essentially, constructivism adheres to a relativist position that focuses upon the development of substantive theory as it emerge from the research investigation (Stiles, 2003:264; Ponterotto, 2005:129). Constructivists believe that reality is constructed in the minds of the individual, rather than it being an externally singular entity (Hasen, 2004:133), and avoid pre-set guidelines and are poised to integrate new insights as they are introduced during the investigation. However, the constructivist position advocates a hermeneutical approach, which maintains that meaning is hidden and must be brought to the surface through deep reflection. The interactive researcher – participant dialogue can stimulate this reflection.

Ponterotto (2005:129), while emphasising the goal of live experience, states that every participant experience occurs within a historic social reality and may be outside the immediate awareness of the individual, but could be brought to consciousness. Perhaps it is more useful that the most suitable approaches to investigation, including various testing techniques that are applied with rigour, as the techniques are developed by the researcher but encapsulate the value of those involved in formulating it (Fellows, & Liu, 2008:19). Thus, a distinguishing characteristic of constructivism is the centrality of the interaction between the investigator and the object of investigation.

Positivists' approach tends to favour techniques such as observation, in-depth interviews and case studies, in an attempt to gather depth and idiographic perspective upon which the phenomenological paradigm relies. Data derived through this approach is arguably characterised by a greater richness than the positivist stance, and allows the research to discover the basis for new ideas and theories (Stiles, 2003:265).

Table 4. 1 Summary of philosophical position

Ontological considerations	
Realist • External world comprises pre-existing hard and tangible structures • Structures exist independent of individual's ability to acquire knowledge	**Relativist** • Existence of multiple realities as subjective construction of mind. • Perception of reality is directed by varying socially transmitted terms.
Epistemological considerations	
Positivist • Application of natural science methods to the study of social reality and beyond. • World confirms to the laws of causation and complex issues can be reduced through reductionism • Emphasize on objectivity measurement and repeatability	**Constructivist – Interpretivist** • Absence of universal truth • Understanding and interpretation come from researcher's own frame of reference. • Uncommitted neutrality impossible • Emphasize on realism of context

Source: Fitzgerald & Howcroft, (1998) and Bryman, (2012)

4.2.3 Pragmatism

Another philosophical position is pragmatism which, according to authors such as Creswell (2009:10) and Easterby-Smith, *et al.,* (2012:32), originated from works of twentieth-century American philosopher, William James (1907; 1979), and John Dewey (1916). To Creswell (2009:10), pragmatism's philosophical view arises out of actions, situations and consequences rather than antecedent conditions. It is often seen as a compromise position between internal realism and relativism. The pragmatist theorist does not accept that there are pre-determined theories or frameworks that shape knowledge and truth, nor can people construct truth out of nothing (Easterby-Smith, *et al.,* 2012:32). This position was argue by Fendt, *et al.,* (2008:478), that the pragmatic approach focus is on tackling pressing and current problems to create constructive knowledge, and subsequent translation of the developed knowledge into action. This is corroborated by Tashakkori and Teddlie (1998) who opine that pragmatism's view is an enthralling rational underpinning of a research that abstains from the truth and reality that has generated heated debates over the years. Tashakkori and Teddlie (1998) further express that pragmatist researchers engage in what is appealing and has value, study them in a way they understand and use the results to generate positive effects within the value system being studied.

Pragmatism is viewed as a valuable perspective in management research since it focuses on processes that are particularly relevant to studies of knowledge and learning and its impact on methods can be seen in the tradition and methods of grounded theory (Easterby-Smith, *et al.,* 2012:32). Conversely, it is a widely accepted philosophical foundation for the mixed methods approach and the third paradigm, based on pragmatist philosophy, which argues that both positivist and constructivist philosophical stances can be successfully combined (Teddlie, & Tashakkori, 2011). Onwuegbuzie and Johnson (2006:52) stressed that pragmatist assumption is based on knowledge or experience and examination, which is the basis of the mixed methods approach to research. These however, differentiate pragmatist from quantitative and qualitative approaches that are founded on positivist and interpretivist paradigms. Pragmatists use diverse methodologies and values, both qualitative and quantitative in nature, flexibly employing 'what works' (Creswell & Plano Clark, 2011).

Creswell (2009:11) agreed that there are various forms of pragmatism, many of which claim that knowledge results from actions, circumstances and effects, rather than antecedent conditions (as in post positivist approach). The author criticises the pragmatic approach as a philosophical basis for mixed methods because it believes in "what works" as solutions to problems. The correct approach should view the research problem as more important than methodological preferences. Tashakkori and Teddlie (1998), argue that a researcher should use all approaches that will shed light on the problem at hand; multiple methods are seen as beneficial. Therefore, pragmatism provides the philosophical underpinning for mixed methods research.

According to Creswell (2009:11), pragmatism provides a philosophical basis for research that has the following characteristics:

- Pragmatism is not committed to any one system of philosophy and reality.
- Individual researchers have a freedom of choice. They are “free" to choose the methods, techniques and procedures of research that best meet their needs and purposes.
- Pragmatists do not see the world as an absolute unity. In a similar way, mixed methods researchers look to many approaches for collecting and analysing data rather than subscribing to only one way (e.g. quantitative or qualitative).
- Truth is what works at the time: it is not based in a strict dualism between the mind and reality, nor is it completely independent of the mind. Thus, in mixed methods research, investigators use both quantitative and qualitative data because they work to provide the best understanding of a research problem.
- Pragmatist researchers look to the "what" and "how" of research, based on its intended consequences (i.e. where they want to go with it). Mixed methods researchers need to establish a purpose for their "mixing," a rationale for their decision to mix quantitative and qualitative data.
- Pragmatists agree that research always occurs in social, historical, political, and other contexts. In this way, mixed methods studies may include a postmodern turn, a theoretical lens that is reflexive of social justice and political aims.
- Pragmatists believe that we need to stop asking questions about reality and the laws of nature

Thus, for mixed methods researchers, pragmatism allows pluralistic approaches to research, different worldviews, and different postulates, as well as different forms of data collection and analysis in a single study.

4.3 RESEARCH APPROACH

In determining what the most appropriate approach is to adopt in research design, critical consideration of various research approaches cannot be overemphasised, particularly how they link to the data collection, analysis to yield results and conclusion to the study being investigated. These in turn, influence the actual research methods that are used to

investigate a problem and to generate dependable data, analyse and interpret through professionally conducted practices (Dainty, 2008:3; Cooper & Schindler, 2008; Swanson & Holton, 2005). As the research process develops, researchers such as Teddlie and Tashakkori (2009:4) classified the research into three categories: quantitative research, qualitative research, and mixed method research. While Fellows and Liu (2008:20) suggest research approaches to be action research, ethnographic, surveys, case studies and experiments. In the same vein, Yin (2002:11) classified research in social sciences into five approaches: surveys, experiments, archival analysis, histories and case studies.
However, the basis for the categorization relates to the different perspectives provided by different types of research fields. In addition, definitions of each style vary and such, the boundaries between the research approaches are not well defined. In light of this, this study will provide a brief description of the following research methods: quantitative, qualitative, mix method, case study and ethnographic research.

4.3.1 Quantitative Research

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".* Quantitative research is employed in modern science, which starts with the specific theory and hypotheses, and where researchers quantitatively measure and analyse based on established research procedures (Swanson & Holton, 2005; Teddlie & Tashakkori, 2009:4). Similarly, Brannen (1992) asserts that quantitative research is concerned with attitudes and large-scale surveys, rather than simply with behaviour and small-scale surveys. While Fellows and Liu, (2008:27) argue that quantitative research approaches seek to gather factual data, to study the relationships between facts and how such facts and relationships concur with theories and the findings of other researches in the extant literature.
The three types of quantitative research are experiments, quasi-experiments and surveys (Creswell, 2009:146). The effectiveness of the selected types depends mainly on the nature of the research. The survey technique is the most widely used method in social science and also the most relevant to this study. It typically involves cross-sectional and longitudinal studies using questionnaires or interviews to collect large amounts of data. The most common of this technique are mail (use of online Survey Monkey), personal and telephone survey (Creswell, 2009:148; Rubin & Babbie, 2010; Bryman, 2012:162). Several merits and demerits of survey methods are identified by many authors notably

(Creswell, 2009:148; Rubin & Babbie, 2010; Bryman, 2012:162), and these advantages and disadvantages are collated in table 4.2.

Table 4. 2 Advantages and Disadvantages of Survey Methods

Types of survey	**Advantages**	**Disadvantages**
Mail survey	• Cost is low compared to other methods • High degree of respondents anonymity • Wide geographical reach • Relatively low cost of Processing	• Low rates of response • Require easily understood questions and instructions • Lack of chance to probe for further or clarity of answers • Greater respondents bias • High amount of uncompleted questions
Personal survey	• Allows high flexibility in the questioning process • Interviewers have control of the interviewing situation • High response rate • Possibility of collecting supplementary information	• Higher cost than mail questionnaire • Potential interviewers bias due to high flexibility • Lack of anonymity; hesitant to disclose personal data • Time consuming
Telephone Survey	• Moderate cost • Increase speed and time of data collection • High response rate • Increase quality of data	• Hesitancy to discuss sensitive data on phone • High chance of respondents terminating interview earlier • Less chance for supplement Information

4.3.2 Qualitative Research

Qualitative research has its roots in the social sciences, it is used where the researchers approach the research from an observer's perspective, with data collection and interpretation through contact with the field (Miles & Huberman, 1994 cited in Warfield, 2005:29). According to Fellows and Liu, (2008:27) qualitative approach tends to gain insight into people's perceptions of "'*the world', whether as individuals or groups''*. Amaratunga, *et al*., (2002:20) further stress that qualitative researchers investigate the beliefs, understandings, opinions and views of the respondents. Conversely, Bryman (2012:380) explains qualitative research as a research strategy that places emphasis on words rather than quantification in collection and analysis of data.

Information gathered in qualitative research can be classified under two categories, namely exploratory and attitudinal research. Exploratory research is used when the researcher has a limited amount of knowledge about the research topic (Bryman, 2012:385). The purpose is closely linked with the need for a clear and precise statement of the recognised problem. Attitudinal research, on the other hand, is used to subjectively evaluate the opinion of a person or a group of people towards a particular attribute, variable, factor or question. However, the objectivity of qualitative data is often questioned by positivist (quantitative) researchers (Fellows & Liu, 2008:27). According to Hancock (1998), the main examples of methods of collecting qualitative data are individual interviews, focus groups, direct observation and case studies.

There are several advantages as well as disadvantages involved in using a qualitative research method. Among various advantages are: it facilitates in-depth study, produces overwhelming detailed information with a smaller number of people and provides a great understanding of the topic under study (Amaratunga, *et al.,* 2002:20). Conversely, analyses of quantitative data are considerably more difficult as it often requires a lot of filtering, sorting and other manipulations to make the data suitable for analytical techniques, thereby making the researcher intimately involved in all stages of the research (Fellows, & Liu, 2008:27). Flick (2009), Fellows and Liu (2008:27), and Bryman (2012:382) listed a few examples of disadvantages to include: 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 subjectivity, and that a variety of external environmental variables are likely to impact on the data and the results. Table 4.3 presents the comparison of qualitative and quantitative research strategies.

Table 4. 3 Comparison between quantitative and qualitative research approach

Point of Comparisons	**Quantitative Research**	**Qualitative Research**
Alternative labels	Positivist, rationalistic or functionalist.	Constructivist, naturalistic-ethnographic or interpretative.
Scientific Explanation	Deductive	Inductive in nature
Data classification	Objective	Subjective
Objective/purpose	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.	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.
Sample	Usually a large number of cases representing the population of interest. Randomly selected Respondents	Usually a small number of non-representative cases. Respondents selected to fulfil a given quota or requirement.
Data collection	Structured interview, self-administered questionnaires, experiments, structured observation, content analysis / statistical analysis	Participant observation, semi and unstructured interview, focus groups, conversation and discourse analysis.
Data analysis	Statistical usually in the form of tabulations. Findings are conclusive and usually descriptive in nature	Non-statistical
Outcome	Used to recommend a final course of action.	Exploratory and / or investigative. Findings are not conclusive and cannot be used to make generalisations.

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

4.3.3 Case Study Research

Gummesson (2007: 87) defines a case study research as a method where cases from real life are used as empirical data for research, especially when knowledge of an area is sparse or missing. Yin (2009:10) states that a case study is used when a "how" or "why" question is being asked about a current set of events of which the researcher has little or no control, and the boundaries between phenomenon and context are not clearly evident. Fellows and Liu (2008:158) explain that interviews and collection of hard documentary data characterized case studies research. The authors argue further that questionnaires are merely employed to gain an understanding of the general situation of which the case being studied is a particular instance. A case study yields deep but narrow results and generalising the findings of a case study requires the use of triangulation (Fellows & Liu, 2008:158).

In essence, the philosophy underpinning the research is located within the pragmatic worldview, which is applicable to Mixed Method, which is a body of knowledge that enables researchers to look towards both qualitative and quantitative approaches when collecting and analysing data (Creswell, 2009:11; Teddlie & Tashakkori, 2009:14).

4.3.4 Ethnographic Research

Ethnographic research is a type of research where the researcher is 'immersed' into the research setting and becomes part of the group under study and observes subjects' behaviours (participant observation), statements, etc. to gain insights into what, how and why their pattern of behaviour occurs (Fellows & Liu, 2008:22; Easterby-Smith, *et al*., 2012:50). The empirical element of ethnography requires an initial period of questioning and discussion between the researcher and the respondents, to facilitate the researcher's gaining understanding of the perspectives of the respondents. Easterby-Smith, *et al*., (2012:51) argue that ethnographic research is a strong form of constructionism, since most outsiders who are new to an organisation or group will encounter things that they do not understand.

Ethnography has its root in anthropology, and it takes distinction from what are known as *'emic and etic'* perspectives, which was first coined by the American linguist, Kenneth Pike (1954) cited in (Easterby-Smith, *et al*., 2012:51). The author further explains that *emic* refers to sound within a language which can only be distinguished by the speakers of that language; and *etic* refers to the features of a language that are easily identified by outsiders, but are largely inaudible to people who speak that language. This distinction has led to the view that better insights can be gained into management and organisation through combining insider and outsider perspectives (Easterby-Smith, *et al*., 2012:51).

Amaratunga, *et al*., (2002:23) express that it is important for a researcher who is concerned with the experience of people, the way they think, feel and act, to share their experience, which is precisely the outlook prescribed as 'ethnographic research'. This view corroborates the opinion of Waddington (1994) who asserts that ethnography is best suited for research which emphasises the importance of human interpretations where the phenomenon under investigation is generally obscure from public view and assures that insider perspective would enhance the existing knowledge. Easterby-Smith, et al. (2012:52) noted that it is often possible to combine observation of meetings with interviews of participants, since it is difficult to conduct full ethnographic research due to access restrictions in many organisations.

Even though ethnography adheres chiefly with observation and recording of human activity, most practitioners of the method employ principle of triangulation (Amaratunga, *et al.*, 2002:23) *… which is discussed in subsequent section of this thesis*.

Thus, these various research methods discussed in sections 4.2.3.1 to 4.2.3.4 fall into two classical and distinctive epistemological positions, which are qualitative and quantitative research methods. The combination of the two approaches is termed triangulation (Mixed Methods).

4.4 MIXED METHOD RESEARCH

Mixed Methods research can be viewed as an approach which draws upon the strengths and perspectives of qualitative and quantitative methods, recognising the existence and importance of the physical, natural world as well as the importance of reality and influence of human experience (Creswell, Clark, Gutmann & Hanson, 2003:212; Onwuegbuzie & Johnson, 2006:51; Grafton, Lillis, & Mahama, 2011:6). Mixed Method research combines or mixes quantitative research and qualitative research in the same study or a series of studies in collection of data, analysis and inferences (Swanson & Holton, 2005; Johnson, Onwuegbuzie, & Turner, 2007:123; Teddlie & Tashakkori, 2009:4). Mixed Method research sometimes uses the case study approach in data collection. The concept of mixing methods was first introduced by Todd D. Jick, in 1979 (Ostlund, Kidd, Wengstrom, & Rowa-Dewar, 2011:370), as a means for seeking convergence across qualitative and quantitative methods within social science research.

Mixed Methods helps to highlight the similarities and differences between particular aspects of a phenomenon. Researchers' interest in, and expansion of, the use of mixed methods designs have most recently been fuelled by pragmatic issues, like the increasing demand for cost effective research and the quest to move away from theoretical research to research which meets policymakers' and practitioners' needs (Ostlund, *et al.,* 2011:370).

Swanson and Holton (2005) classified Mixed Method research into four types. The first type, complementary, combines the results of one method with the results of the other method; the second type, development, uses the results from one method to develop or inform the other method; in the third type, initiation, the result from one method is recast to questions or results from the other method. Lastly, the fourth type, expansion, is where a different method is used to extend the breadth or range of inquiry. Teddlie and Tashakkori, (2009:151) further classify Mixed Method research into five families namely; Parallel, Sequential, Conversion, Multilevel and Fully integrated Mixed Method design.

Parallel mixed method is a research design where at least two parallel and relatively independent qualitative and quantitative data collection are planned and implemented to answer related questions to the same research; this is represented in Figure 4.2.

Sequential mixed designs uses the procedure from qualitative to develop the research questions for the quantitative phase of the research chronologically (Figure 4.3). While Conversion mixed designs are multi-strand parallel designs in which mixing of qualitative and quantitative approaches occurs when one type of data set is transformed and analysed both qualitatively and quantitatively (Figure 4.4). Multilevel mixed designs are multi-strand designs in which qualitative data is collected at the level of analysis and quantitative data collected at another level in a parallel or sequential manner. The fifth, fully integrated mixed design, is a multi-strand parallel design in which mixing of qualitative and quantitative approaches occurs in an interactive manner at all stages of the study, as represented in Figure 4.5 (Teddlie & Tashakkori, 2009:151-157).

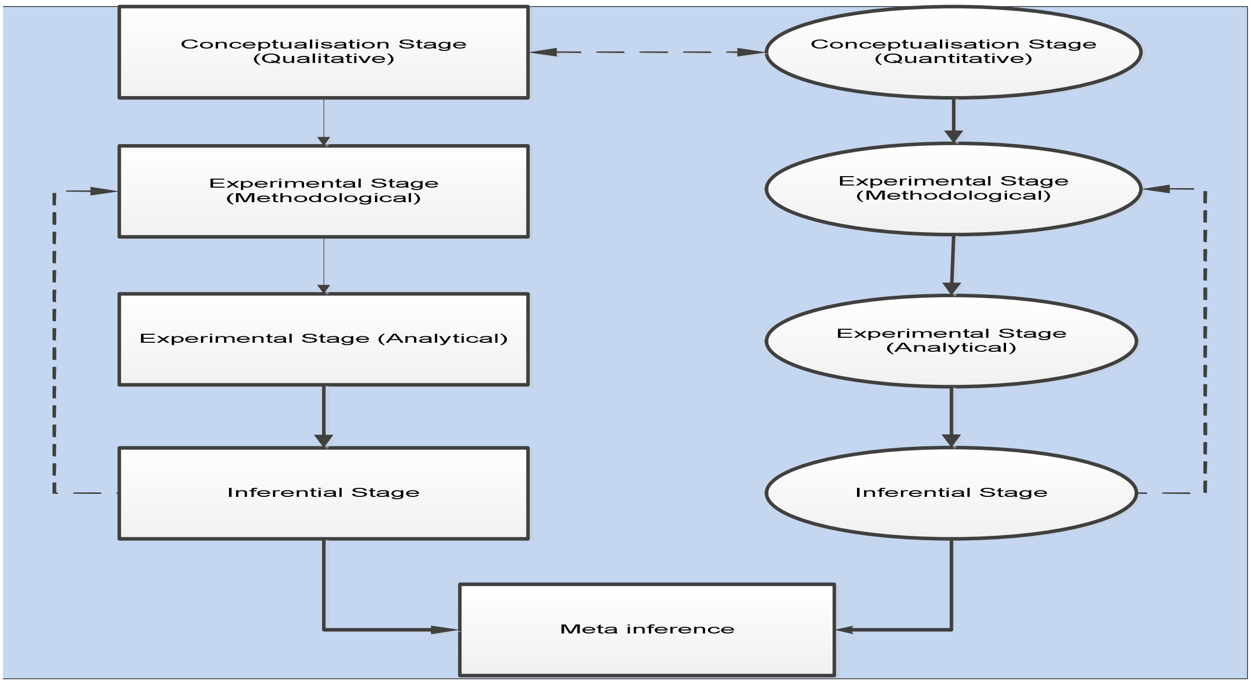

Figure 4 2: Parallel Mixed Method design (adapted from Teddlie & Tashakkori 2009)

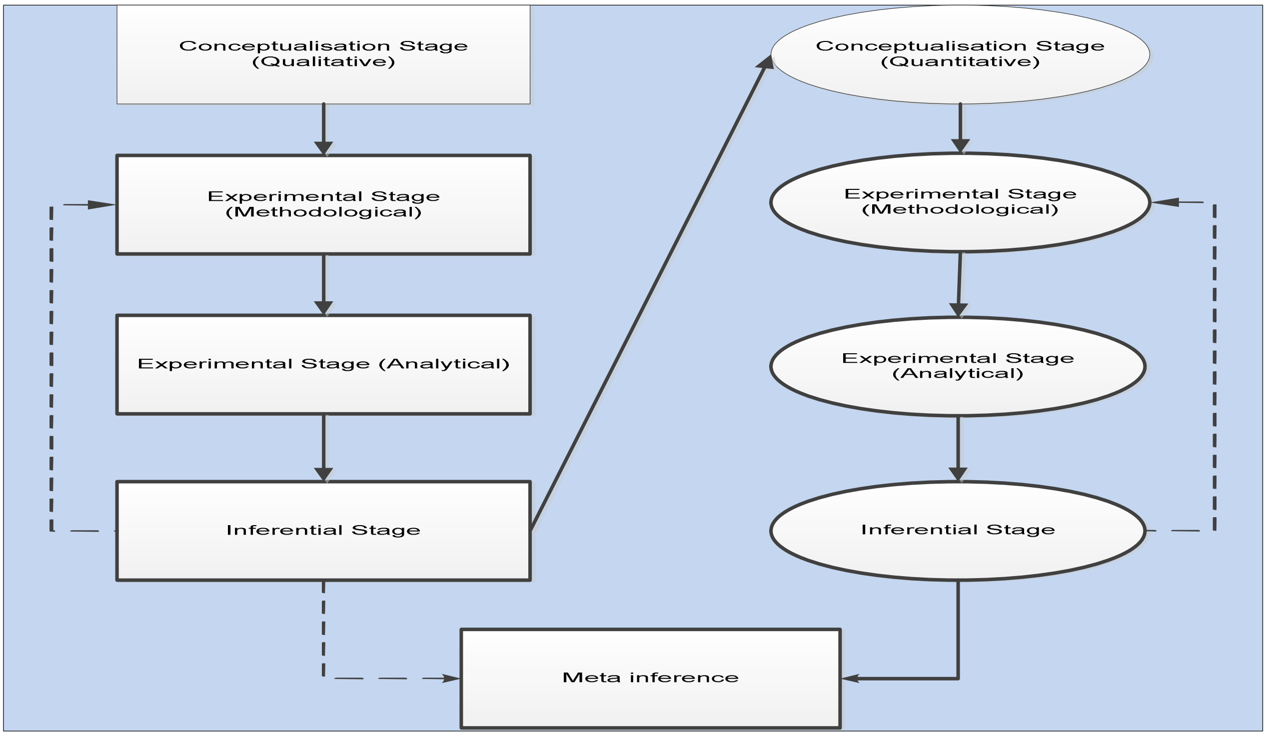

Figure 4 3: Sequential Mixed Method design (adapted from Teddlie & Tashakkori 2009)

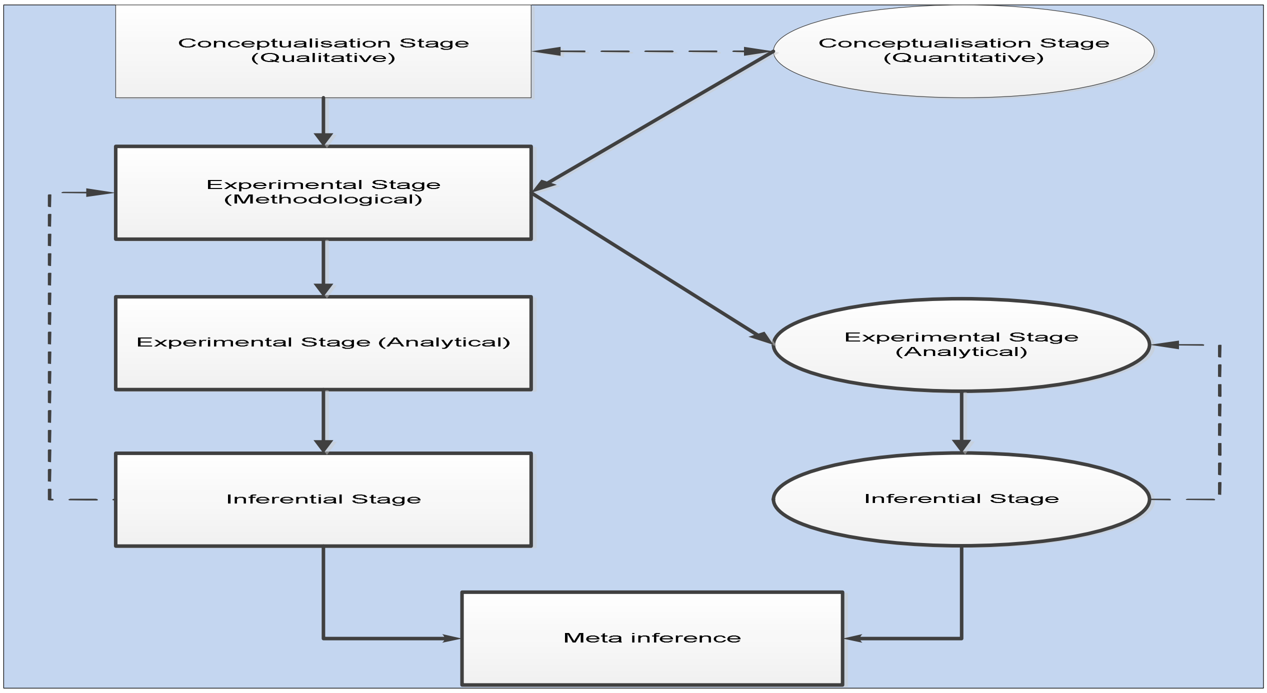

Figure 4 4: Conversion Mixed Method design (adapted from Teddlie & Tashakkori 2009)

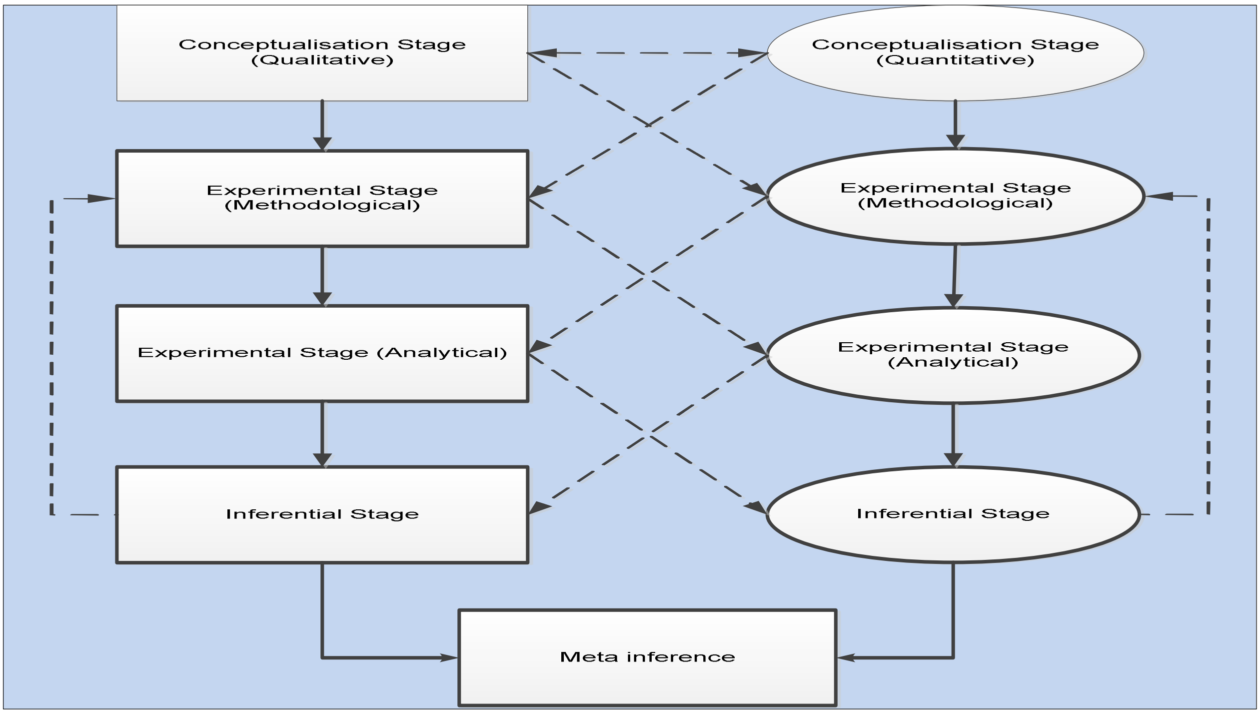

Figure 4 5: Fully integrated Mixed Method design (adapted from Teddlie & Tashakkori 2009)

4.4.1 Strength and challenges of using Mixed Methods

Section 4.4 has exhaustively discussed the potentials of Mixed Methods to throw new perspectives on research questions to increase the credibility of the results and to demonstrate generalisability. However, extant literatures have identified some strengths and challenges of using mixed methods, these are summarised by Easterby-Smith, *et al*., (2012:63) as detailed in table 4.3.

Table 4. 4 strength and challenges of mixed methods

Strength	**Challenges**
• Increase confidence and credibility of results; • Increase validity; • Stimulate creative and inventive methods; • Can uncover divergent dimensions; • Can help synthesis and integration of theories; • May serve as critical test of competing theories; • Can combine confirmatory and exploratory research at the same time; • Present greater diversity of views; and • Provide better inferences.	• Replication is difficult to achieve; • The research design must be relevant to the research question; • They provide no help if the researcher ask the wrong questions; • They require more resources than single method studies; • Their use require competent overall design; • The 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

Source: Easterby-Smith, *et al*. (2012:63)

4.5 TRIANGULATION

Combining both quantitative and qualitative research methods has proven to be more powerful than a single approach and very effective (Ostlund, *et al.,* 2011:370). According to Onwuegbuzie and Johnson (2006:53), Triangulation is a process of seeking convergence and corroboration of findings from different methods that study the same phenomenon. To Ostlund*, et al.,* (2011:370), Triangulation is a methodological metaphor for drawing inferences from qualitative and quantitative findings originating from Mixed Method analysis. This approach offers researchers a great deal of flexibility whereby theories can be developed qualitatively and tested quantitatively or vice versa. The main aim of using the triangulation method is to improve the reliability and validity of the research outcomes (Easterby-Smith, *et al.,* 2012:61). Brannnen (1992), drawing on the work of Denzin (1978) cited in Teddlie & Tashakkori (2009:75), argued that triangulation means more than just one method and data collection but also includes investigators and theories. Teddlie and Tashakkori (2009:75) then outlined four different types of triangulation as follows:

- Data Triangulation: involves the use of a variety of data sources in a study.
- Methodological Triangulation: the use of multiple methods to study a single problem.
- Investigator Triangulation: involving several different researchers in a single study.
- Theory Triangulation: the use of multiple perspectives to interpret a single set of data.

Triangulation helps to describe the logical relations between the qualitative and quantitative findings and the theoretical concepts in a study. It demonstrates the way in which both qualitative and quantitative data can be combined to facilitate an improved understanding of particular phenomena and can be used to help generate new theory (Erzberger & Kelle, 2003). In Figure 4.6, the convergence points of the triangle represent theoretical propositions and empirical findings from qualitative and quantitative data while the sides of the triangle represent the logical relationships between these propositions and findings. The nature and use of the triangle depend upon the outcome from the analysis, whether that be convergent, where qualitative and quantitative findings lead to the same conclusion; complementary, where qualitative and quantitative results can be used to supplement each other or; divergent, where the combination of qualitative and quantitative results provides different (and at times contradictory) findings. Each of these outcomes requires a different way of using the triangulation metaphor to link theoretical propositions to empirical findings (Erzberger & Kelle, 2003).

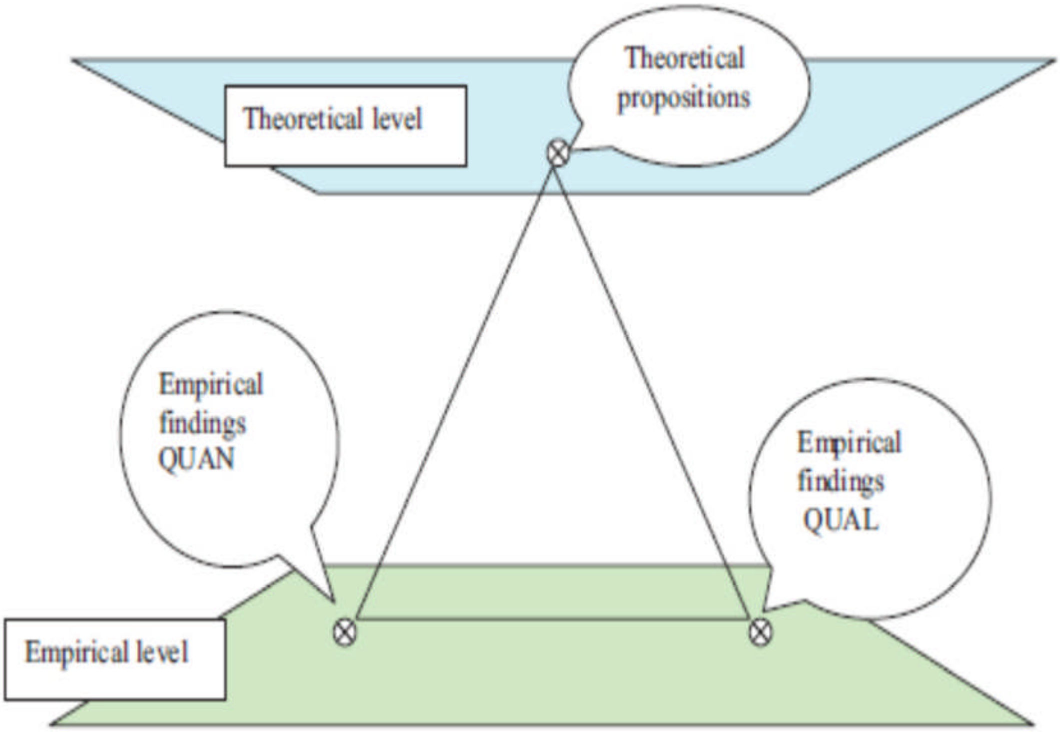

Figure 4 6: Triangulation triangle (adapted from Ostlund, *et al.* 2011)

4.6 Chapter summary

This part of this thesis has provided explanations into the methodological underpinning of this research, and presented the merits and demerits of each research approach upon which this study is conducted. The chapter also explains the need for adopting Mixed Methods Research for data collection to ensure valid and generalisable findings. The next chapter presents the methods employed for the research and provides justification for the adopted techniques towards achievement of viable and reliable results.

CHAPTER FIVE
RESEARCH METHODS

5.1 INTRODUCTION

In the preceding chapter (Chapter 4), different research philosophies and research approaches were discussed and arguments in favour of the most appropriate ones for this research was advanced and explicitly referenced. This chapter however, explains the techniques adopted for this research, and procedures used to gather and analyse data related to research questions. It also explains the process of questionnaire development and administration, sampling techniques and methods of data analysis. Coupled with the application of sustainability concepts into construction processes, the methodology represents a unique contribution to the study of affordable housing construction.

5.2 THE STUDY PHILOSOPHICAL STANCE

Research philosophical approaches were described in sections 4.2.1, 4.2.2 and 4.2.3 of this thesis to provide background knowledge on the use of each of the philosophical stances. However, this study adopts the *Constructivist* philosophical stance. The primary objective of this research is to investigate the perspectives (thoughts and feelings) of individual stakeholders and government on the issues addressed in this research. Fundamentally, the study does not set out to test pre-existing theory, however, testing the research question relies upon qualitative data with robust open interviews with the roleplayers on sustainable housing construction, in order to discover and understand the individual and shared sense of meaning regarding their involvement and commitment to delivery of sustainable housing. Achievement of this objective rests on the analyses of factors that enhance construction of sustainable buildings, gathered through quantitative techniques and the understanding of individual and shared meaning, rather than explaining underlying mechanisms.

It is acknowledged that this study is inductive, rather than theory testing, hence the adoption of a *'Constructivist – Interpretivist'* epistemological position, due to its unique characteristics discussed in section 4.2.2.2. Figure 5.1 summarises the key aspects of this study as applicable to the *Interpretivist* philosophical stance of the research.

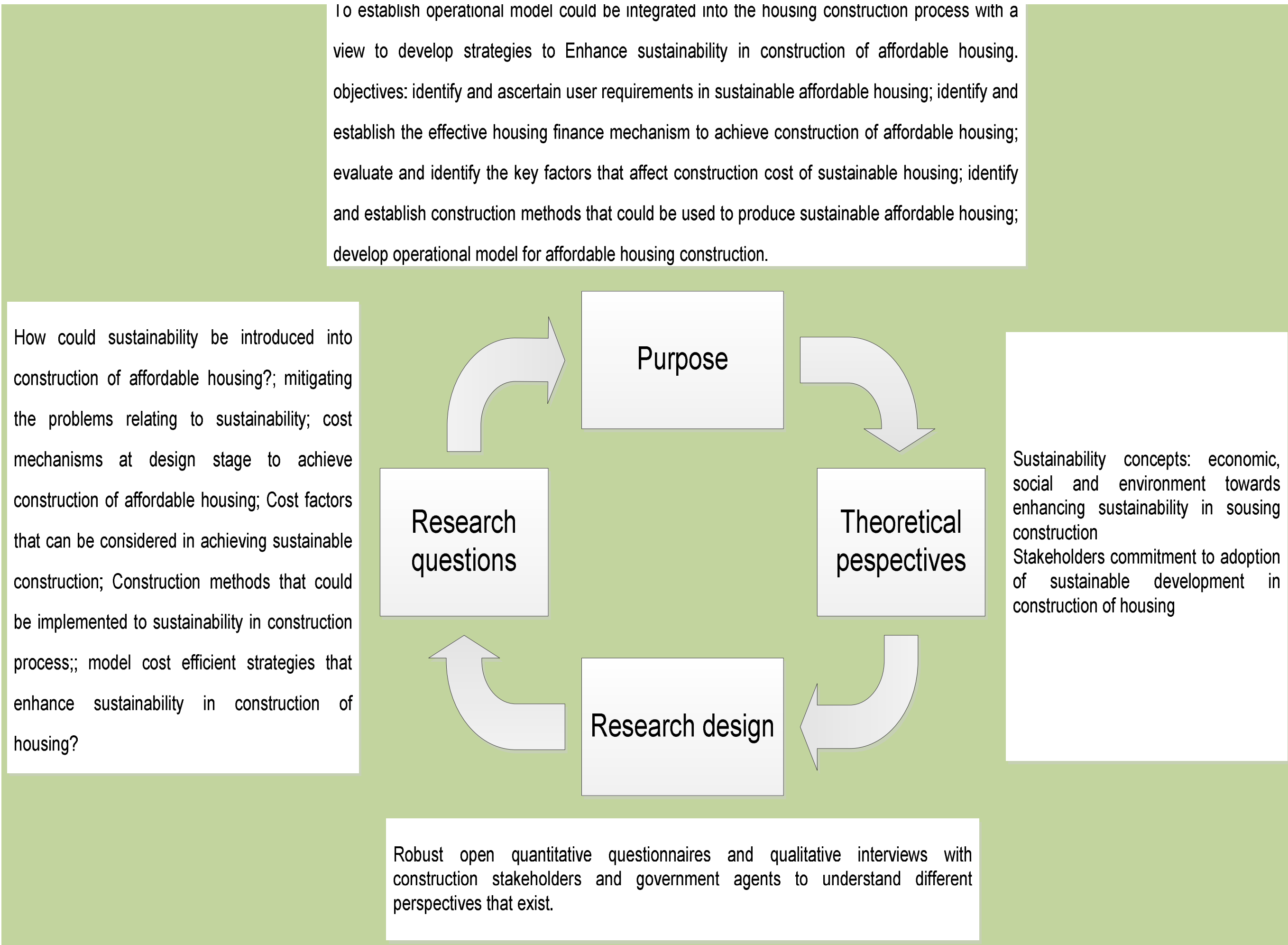

Figure 5. 1: Essential aspects of the research

5.3 JUSTIFICATION OF SEQUENTIAL MIXED METHOD DESIGN APPROACH

The rationale for pursuing mixed method research designs rests largely on the premise that the weaknesses in one method will be compensated by the counter-balancing strengths of the other (Jick, 1979). The advantages to mixed method research rest on the development of a research strategy that is effective in exploiting the advantages of quantitative and qualitative methods, while neutralising the "costs" or "risks" associated with each method (Grafton, *et al.,* 2011:11). Further to the merits of Mixed Method design, Creswell (2009:85) provides an example of a scenario in which Mixed Method approach can be situated viz. where for instance the researcher wants to both generalise the findings to a population and develop a detailed view of the meaning of a phenomenon or concept for individuals, the researcher may first explore generally in a qualitative manner to learn about which variables to study, and then study those variables with a large sample of individuals quantitatively.

Onwuegbuzie and Johnson (2006:53) describe sequential Mixed Method as a contextual overlaying strategy, where qualitative approaches are used to collect contextual information for facilitating the interpretation of quantitative data or reconciling findings. It has been argued that a characteristic of truly mixed method studies involves integration of the qualitative and quantitative findings at some stage of the research process, be that during data collection, analysis or at the interpretative stage of the research (Kroll, & Neri, 2009 cited in Ostlund, *et al.,* 2011:370). However, in studying the variables that enhance sustainable development practices in construction of affordable housings, the use of only one approach will be limiting, as issues relating to construction and delivery of affordable buildings have to be explored from the perspectives of the various stakeholders. This scenario mirrors this research and shows that the approach intended for this research is appropriate.

One of the advantages of the Mixed Method approach is that the techniques of qualitative and quantitative domains, which are interlinked, will help to maximize the knowledge yield of the research outcomes (Teddlie & Tashakkori, 2009:33). In addition, Mixed Method allows the researcher to discover and justify the model components within one study. In addition, qualitative techniques permit gathering of data that is robust in details, which will have a great influence on the research output.

When qualitative and quantitative methods are mixed in a single study, one method is usually given priority over the other. In such cases, the aim of the study, the rationale for employing Mixed Method, and the weighting of each method determine whether, and how, the empirical findings will be integrated. This is less challenging in sequential Mixed Method studies, where one approach clearly informs the other (Ostlund, *et al.,* 2011:370). Sequential Mixed Method design is less complicated to conduct when compared with other methods, though challenging. This is because it is easier to keep each aspect of the research separate, and the studies typically unfold in a more predictable manner (Teddlie & Tashakkori, 2009:153).

Thus, a Sequential exploratory strategy (Figure 4.3) is proposed for this research, which starts with in-depth interviews to (qualitative), to test the research conceptual framework and to capture as much of the construction practitioners' perspective towards adopting sustainable construction strategy in construction of affordable housing. Information obtained from this process is then fed into the development of a questionnaire survey (quantitative) to incorporate several conceptually related questions covering each of the various dimensions identified through the qualitative investigation. An overall outline of this approach is presented in the flowchart shown in Figure 5.2.

As indicated in the preceding section, an overall positivist paradigm is being adopted in this research and therefore the greater priority in this research is placed on the quantitative aspects. This is because this approach best facilitates the comparison of sustainability practices among organisations on the same basis and allows the research objectives of empirically examining how sustainable construction concepts can be integrated into building construction process to enhance housing sustainability.

Applying this approach represents a significant departure from the approaches applied in previous researches on sustainability in construction, which makes this research contribute significantly to knowledge on sustainability related research in construction industry.

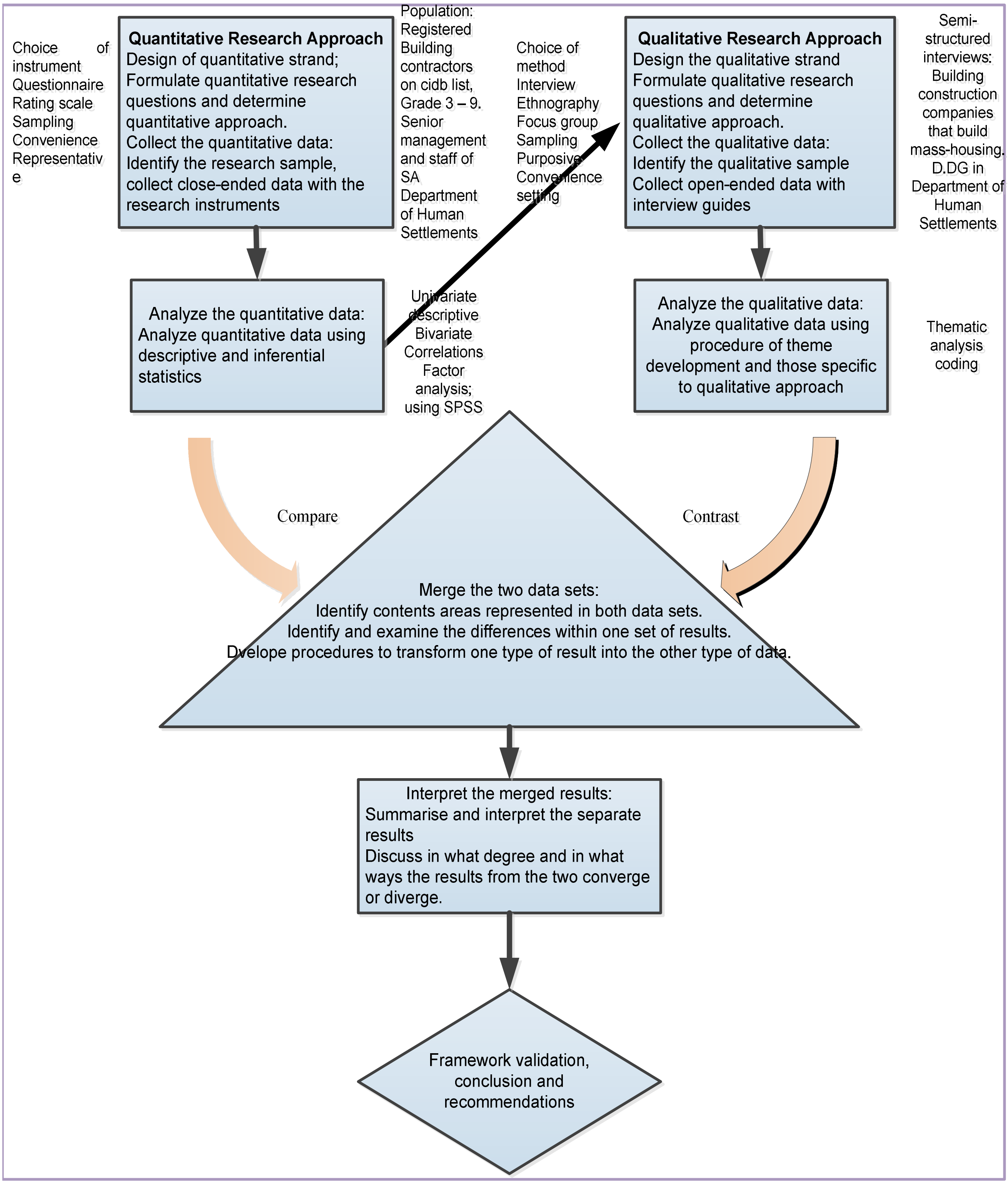

Figure 5. 2: Flowchart of the stages in implementing sequential Mixed Method design

5.4 RESEARCH DESIGN

Methodology is the most demanding aspect of the research work because findings and conclusions will be drawn from the results generated through the methodological approaches chosen for the research, and this may be rendered unacceptable if they were drawn from research processes founded upon faulty methodology.

Robson (2002) identifies five inter-related phases towards a decent scientific research design:

i- Purpose – what is the achievement?

ii- Theory – the theory which the study is based on, including the design of research and the analysis of findings.

iii- Research questions – what is the statement of possible findings and what the expectation of these findings is.

iv- Methods – how to collect, analyse and validate the findings and how to show its reliability.

v- Sampling strategy – how, where and when the input data should be collected and how the sample should be justified.

A similar division of phases was done by Andersson and Borgbrant (1998), where research questions, methods, sampling of data and findings are interacting with each other during the main moment of research performance; research design, performance and reporting. Atkin and Wing (2007) expressed that research is an interactive and continuous process during the performance, it is a learning process but with sufficient efforts to plan and design the research, especially with research questions and method approaches.

Conducting scientific research of this nature, it is more likely to reach adequate and scientifically proved findings of the research using a mixed methodological research approach. In order to achieve the aim of this research, an overall constructivist position was adopted. It was shown in the literature review that researches into sustainability in the construction context have typically been either qualitative or quantitative. Therefore to provide new perspectives, which is the essence of undertaking research, a mixed method approach was considered appropriate. However, this research adopts the use of the research process explained with Figure 5.3. Further discussion on the research process is provided in subsequent sections of this thesis.

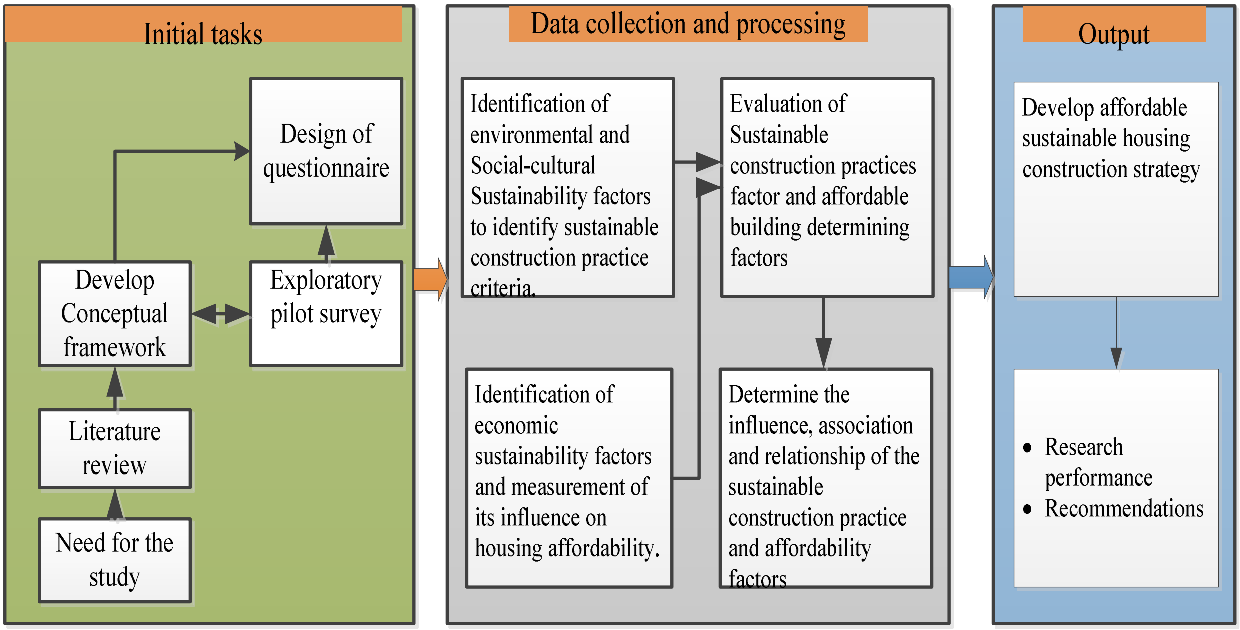

Figure 5. 3: Research Process

5.4.1 Archival Analysis

Archival analysis involves a thorough review of current practices and previous research in the area of sustainability and housing development: impacts of construction professionals' design decisions on sustainable housing; housing users' requirements and the situation in the South African construction industry regarding implementation of a sustainable construction concept; among other related issues, were critically reviewed to provide adequate theoretical underpinning for the research. The literature search also explored the background issues in relation to the development of an operational model for decision making in the sustainable development process.

The review helped to identify gaps in knowledge and formed the basis for developing the framework to aid the enhancement of sustainability in the housing construction process. Information was sought from various sources, including policy reports, industrial and academic publications, the Internet, seminars, workshops and conference notes.

In addition to the development of the research theoretical framework through archival analysis, a conceptual framework for the study was then developed; this was discussed in Chapter 3 of the thesis. Moreover, an exploratory pilot interview was conducted to ascertain the existence of the research problems, and appropriateness of the research conceptual framework.

5.4.2 Data Collection Procedures

Having identified the research methodology considering issues related to validity and reliability, and addressing the ethical implications of a research, it is equally important to know how to acquire and interpret the data required for resolving the overall research problem. Leedy and Ormrod (2005:104) posited four fundamental questions for a researcher to answer of which, if answered correctly, will bring the research into focus. These questions are:

1. What data is needed?
2. Where is the data located?
3. How will the data be secured?
4. How will the data be interpreted?

All of these questions posited by Leedy and Ormrod (2005:104) were given careful attention in the conduct of this research.

The procedure employed for data collection in this study involved the use of mixed methods which encompass the basic process of conducting both qualitative and quantitative research. The motives for sourcing quantitative and qualitative data sets in this study were to increase credibility, validity and generalisability of the research findings (Easterby-Smith, *et al.,* 2012:61). *The focus of this study is to develop a framework for the implementation of affordable housing, to enhance sustainability in the construction process for low income households.* To put the research in the right perspective, the main research question is stated as follows:

> *How could sustainability be introduced in the construction of affordable housing through the knowledge of housing financing, socio-economic aspects of sustainability and construction methods to enhance sustainability in housing delivery in South Africa?*

In view of the research question, it is obvious that the research required more than one data source. The research question therefore calls for mixed methods, and not only that, it demands that the researcher uses designs that could provide answers to different types of problems. Moreover, Figure 5.4 summarises the approaches adopted in this study to effectively work through the four basic questions posited by Leedy and Ormrod (2005:104), which were stated in the first paragraph of this section (section 5.4.2).

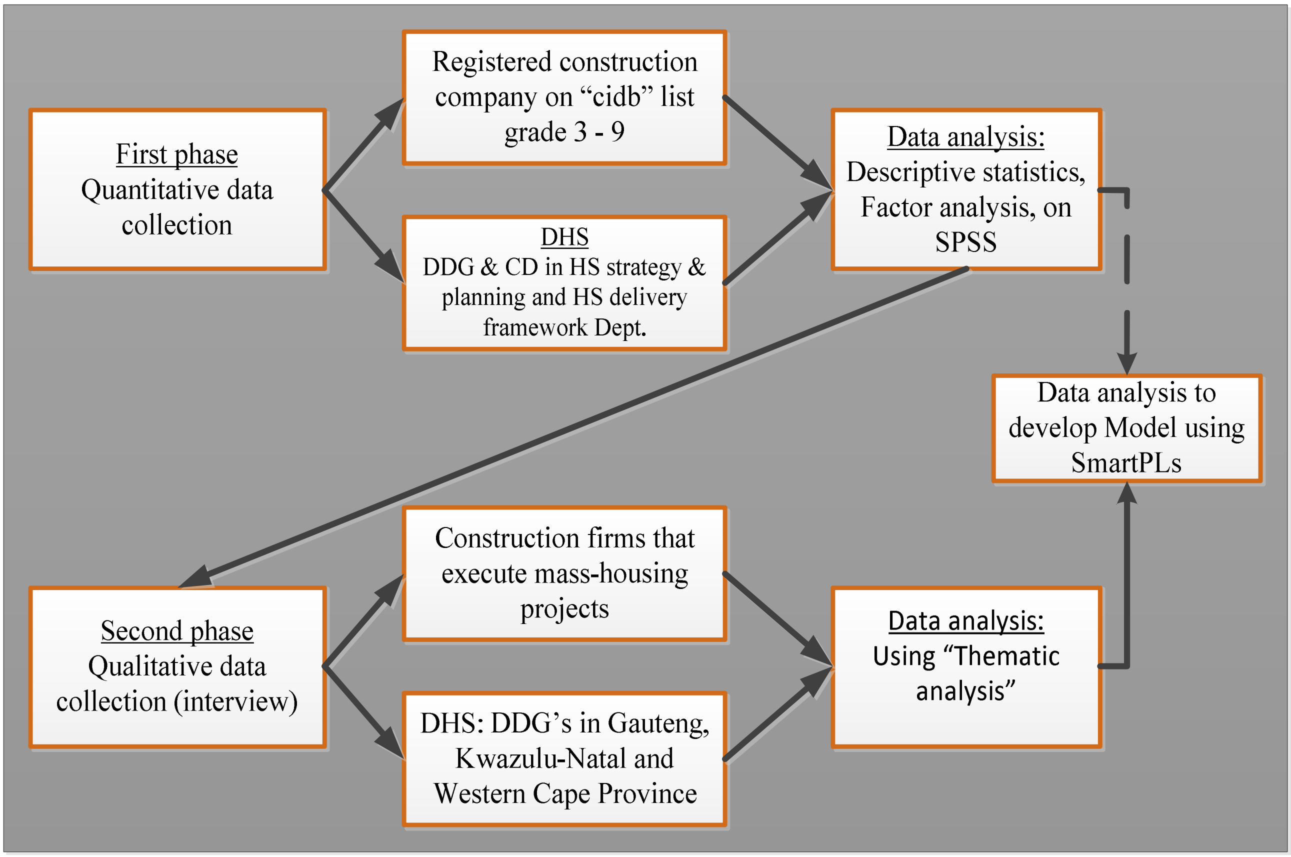

Figure 5. 4: The research data collection procedures

5.4.3 Quantitative Data Collection Phase

Quantitative data collection is mostly done through the survey approach in social and management research. According to Saunders, *et al.,* (2009) and Creswell (2009), survey research offers a quantitative description of trends, attitudes or opinions of a population by studying a sample of that population. Quantitative strategy entails data collection from a sizable population using a well-structured questionnaire instrument. Although authors, notably Saunders, *et al*., (2009), noted that quantitative strategy also extends to the use of structured interviews and observations.

To have better insight into how affordable housing construction is undertaken by the construction industry practitioners and government agencies, and influence of factors considered at all levels of housing development on sustainability, a series of questions are needed to be solicited. The questionnaire approach was adopted in this research in order to obtain a quantitative data set.

Literatures have suggested that the design of a questionnaire must take proper cognisance of the method upon which the questionnaire will be administered. This was, however, adhered to in this study. Further to the format of the designed questionnaire, this research adopts the use of “online Survey Monkey’’, which is an internet-mediated platform for data collection. The Survey Monkey platform allows the researcher to create the research questionnaires and email the questionnaires to the respondents who may respond freely through the Survey Monkey platform. Authors such as Blaxter, *et al.,* (2006) and Creswell (2009:149) have supported the use of an internet-mediated platform for quantitative data collection since it allows for a larger population to be considered at minimal cost, and saves time. Although the mail survey method (online internet-mediated) earlier discussed in section 4.3.1 in the previous chapter has its disadvantages, the benefits outweigh the demerits.

5.4.3.1 Sources of the Quantitative Data

To have access to the respondents (locating the data), registered Building contractors on cidb Grade 3-9 list form the sampling frame. The availability of people with specialised knowledge of the study background and their willingness to make their information available are imperative to the study (Hesse-Biber, & Leavy, 2011: 46). Therefore, what is required in this study is an in-depth understanding of the phenomenon (sustainable construction), which is the characteristic of a case study and by extension, qualitative research. In addition to the multi-case study, a questionnaire survey will be carried out through online Survey Monkey to the construction firms who are registered as General Building Contractors on cidb’s Grade 3-9 list of registered contractors, and the management and employees of the Department of Human Settlements in all nine provinces in South Africa.

5.4.3.2 Development of the Research Questionnaires

A questionnaire survey is one of the most cost effective ways to involve a large number of people in a research process to achieve better results (McQueen, & Knussen, 2002). A questionnaire is a self-administered measuring instrument comprising of closed-ended (respondents choose from a given set of answers) and open-ended questions (respondents record their views and opinion in full). The accuracy and success of questionnaire surveys largely depend on the careful design of its content, structure and the response format. Hence, certain precautions must be taken in 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. Considerable effort was therefore devoted towards this endeavour. The literature review in Chapter 2 guided the formulation of the study questionnaire that was used in the survey of architects and designers, construction organisations and government employees (those in Department of Human Settlement) in RSA.

The questionnaire was divided into four main sections for easy analysis and reporting.

1. Sustainable principle awareness on construction activities and Related Actions: Exploring the level of environmental awareness and attitude of construction practitioners in building design and construction, investigate commitment to sustainable design and construction practices, solicit views on the adoption of environmental approaches during design, especially in the use of building materials and choice of construction method. Investigate the basis of their design decisions to determine the level of importance according to the environment in their usual construction operation.

2. Application of housing financing strategy in housing delivery process: Exploring the adoption of various financing strategies towards delivery of affordable housing, investigating their design decisions to the level of importance attached to the financing concepts, and obstacles to successful delivery of sustainable housing. This section also establishes the factors that influence cost of construction both at design and construction stage of building delivery.

3. Assessment of social sustainability indicators in design and construction of housing: This section was developed to investigate social-sustainability factors that influence sustainable building construction. It is also designed to establish the stakeholders who are responsible for provision of the social indicators highlighted in the questionnaires.

4. Assessment of construction methods and practices that support sustainable construction in building development: This section is to investigate and establish various construction methods that enhance the adoption of sustainability concepts during construction of buildings. It also develops holistic sustainable assessment criteria to assist in the selection of sustainable construction methods for building projects and to establish the influence of the construction methods on cost of construction.

The questionnaire survey was conducted using the electronic mail system. Electronic mail survey system has gained momentum over postal survey due to the increased speed and lower cost of delivery and retrieval.

5.4.3.2.1 The Construct used in design of the questionnaire

The design of questionnaire was based on the information and factors derived from the extensive literature review. The construct comprises of all the variables that make up the conceptual framework presented in Chapter 3 of this thesis.

5.4.3.2.2 Unit of Analysis

Fellows and Liu (2008:99) refer to unit of analysis as the individual or the group, as the case may be that the research anticipates expressing something about when the study is concluded. In the same vein, Easterby-Smith *et al.,* (2012:65) describe unit of analysis as the entity that forms the basis for the research sample. Thus, unit of analysis becomes the emphasis in data gathering for the research. The goal of this study is to establish a sustainable operational framework to be integrated into the housing construction process to enhance sustainability in affordable housing.

Considering this goal, the unit of analysis becomes geared to include: the architect/designers, construction organisations that are registered as building contractors with cidb and the employees of the Department of Human Settlement (DHS) in all nine provinces of South Africa. Having identified the unit of analysis, focus of data collection was directed at them with the research questionnaires. Consequently, contractors on Grade 3-9 level on the cidb list were selected. The organisations in these categories were selected because they are experienced contractors that handle medium to large building projects. Contractors on Grade 1-2 level on the cidb list were excluded since they are mostly new entrants into the industry and they function as subcontractors in most cases. In addition to these, employees of the DHS who are working directly in the Housing Strategy and Planning Department and Housing Delivery Framework Department of the DHS, as well as architects/designers that operates in all nine provinces, were also selected.

5.4.3.4 Piloting the Questionnaire

Creswell (2011) recommends that pre-testing of the questionnaire should be carried out and that it should include groups within the potential research participants. This is to confirm that the data to be collected would be comprehensible and would establish the most productive form of data analysis. However, the first draft of the questionnaire was presented to five scholars who are experts on housing and sustainability research for review. The views of these experts were incorporated into the questionnaires. Subsequently, the questionnaire was presented to the researcher's supervisors and corrections were made based on the research supervisor's comments.

To evaluate the clarity and feasibility of the survey, a second pilot testing of the questionnaire was conducted to some sections of the targeted research participants highlighted in section 5.4.3.2. The sample was randomly selected from the list compiled for the main survey among the research participants that operates within the Western Cape province. Authors, notably Saunders *et al.,* (2009), assert that a piloting questionnaire allows some assessment of the question validity and reliability of the data that will be collected, and demonstrates the methodological rigor of the survey. Subsequently, 30 questionnaires were sent to some research participants, comprising of five architects, five employees of the DHS and twenty contractors. Afterwards, 18 questionnaires were returned representing 60% response rate, and an average of 25 minutes were taken to complete the questionnaire by the respondents. It was therefore considered unnecessary to reduce the number of questions in the questionnaire. Moreover, feedback from the respondents led to the re-wording of some of the questions, prior to its administration for the main study.

5.4.3.5 Sampling for the Main Study

Following the pilot study, an extensive questionnaire survey was undertaken. As suggested by researchers such as (Babbie, 1990; Onwuegbuzie & Collins 2007), sampling is essential for researchers to decide on the number of participants from which inference will be drawn, and the techniques to adopt in their selection (sampling method) because of constraints of time and cost. Summarily, sampling provides a practical means of enabling the data collection and processing in a research study to be carried out while ensuring that the sample provides a better representation of the study population (Fellows & Liu, 2008:159). Therefore the sampling frame for this study is; architectural and design firms who have their names published on ''SA Professions and Projects Register (2014)'', general Grade 3-9 building contractors on the cidb register of contractors, and employees of the DHS earlier stated in section 5.4.3.1. The sampling population for architects and general building contractors is shown in Table 5.1 and Table 5.2. Six (6) employees were selected in each of the DHS in all nine provinces to provide information on the subject of the research from government's perspective based on the practice in the province they represent.

Table 5. 1 Population of Architects on SACAP list by Province

Province	Registered Architects all category	Professional Architect
Eastern Cape	608	204
Free State	276	110
Gauteng	3536	1418
KwaZulu Natal	1281	399
Limpopo	229	31
Mpumalanga	244	46
Northern Cape	95	29
North West	161	46
Western Cape	2370	976
TOTAL	**8800**	**3259**

Source: SACAP 2013/2014 Annual Report (2014:35)

Table 5. 2 Population of general building contractors on cidb register

Province	cidb Grade							
	3	4	5	6	7	8	9	**Total**
Eastern Cape	70	86	55	58	30	11	1	311
Free State	26	40	35	39	12	6	1	159
Gauteng	153	202	163	209	118	59	32	936
KwaZulu Natal	170	217	142	142	56	17	0	744
Limpopo	50	116	74	92	42	8	0	382
Mpumalanga	39	43	54	64	21	4	2	227
Northern Cape	14	18	10	13	5	1	0	61
North West	51	71	32	35	14	7	0	210
Western Cape	38	73	38	51	31	12	10	253
TOTAL	**611**	**866**	**603**	**703**	**329**	**125**	**46**	**3283**

Source: cidb official website (May, 2015)

Following the research population in Table 5.1 and Table 5.2, it may not be possible to obtain data from all the targeted populations, hence, sampling is essential for the questionnaire survey to be a representative of the population and to have a sample that can be generalised. To determine a suitable representative sample, the formula from Czaja and Blair (cited in Ankrah, 2007; Akadiri, 2011) was applied:

$$ss = z^2\ x\frac{p(1-p)}{c^2}$$

Where;
ss = sample size
z = standardised variable
p = percentage picking a choice, expressed as a decimal
c = confidence interval, expressed as a decimal

To decide the sample size for a given level of accuracy, the worst case percentage picking choice (p) of 50%, assumed by Czaja and Blair and used by other researchers notably (Ankrah, 2007; Akadiri, 2011), was used and a 95% confidence level was assumed with a significance level of α = 0.05; confidence interval (c) of ±10% and z =1.96 Therefore:

$$ss = 1.96^2\ x\ 0.5\frac{(1-0.5)}{0.1^2}$$

ss = 96.04.

Therefore, the required sample size from all the targeted populations is 96 participants. However, this figure is to be used to generate a new sample size from the research population using the formula;

$$new\ ss = \frac{ss}{1+\frac{ss-1}{pop}}$$

Where; *pop* is the population
Therefore:

$$new\ ss = \frac{96.04}{1+\frac{96.04-1}{6542}}$$

new ss = 94.66, *approx*. = *95*

From the calculation, the sample size for this study was estimated to be 95 participants from the research population. Ankrah (2007); Fapohunda (2009); Akadiri (2011) and Oyewobi (2014) note difficulties in obtaining responses from construction professionals, particularly for research questionnaire survey. Consequently, Idrus and Newman (2002) and Takim *et al.,* (2004) considered a survey response within the range of 20% - 30% to be adequate for researches that involve the construction industry. Therefore, it was necessary to assume a conservative response rate to account for non-response. Thus, 30% was taken to be the highest boundary and the sample survey was calculated as:

$$survey\ ss = \frac{new\ ss}{response\ rate}$$

$$survey\ ss = \frac{95}{0.3} = 316.66$$

The survey sample size is therefore approximately 317 architects and construction organisations.

Based on the calculated new sample size, a random selection of architects and construction organisations was made from South Africa Council for Architect Profession Register and Construction Industry Development Board (cidb) South Africa to provide a list of 317 participants for the survey. Table 5.3 shows the breakdown of the new sampled survey participants based on class of work and province.

Table 5. 3 list of construction industry professional surveyed

Province	Professional Architect	Construction organisation (cidb Grade)							
		3	4	5	6	7	8	9	**Total**
Eastern Cape	10	3	4	3	3	1	1	0	25
Free State	5	1	2	2	2	1	0	0	13
Gauteng	68	7	10	8	10	6	3	2	114
KwaZulu Natal	19	8	10	7	7	3	1	0	55
Limpopo	1	2	6	4	4	2	0	0	19
Mpumalanga	2	2	2	3	3	1	0	0	13
Northern Cape	1	1	1	1	1	0	0	0	5
North West	2	3	3	2	2	1	0	0	13
Western Cape	47	2	4	2	2	1	1	1	60
TOTAL	**155**	**29**	**42**	**32**	**34**	**16**	**6**	**3**	**317**

5.4.3.6 The Main Study Questionnaire Administration and Collection

The sample used for the questionnaire administration for professionals in the construction industry was drawn from the database of architects on the SACAP register and list of contractors registered with cidb, while the list of sample employees of the Department of Human Settlements was obtained from the official website of each of the provinces. The active contact details of architects and contractors provided on the SACAP and cidb databases were obtained, and provide the platform upon which the questionnaire survey was conducted. An invitation letter to participate in the survey was sent via email to the targeted architects, general building contractors and employees of Department of Human Settlements to forestall non-response and to conduct the survey with utmost ethical standard. This was done on the 7th July 2015 and after one week of sending the invitation letter, 25% of the targeted sample size pledged their readiness to participate and those that did not respond were contacted through telephone calls as follow-up. The phone calls took place from 15th – 22nd July 2015. Further to the follow-up calls, 83% of the sample size agreed to participate. Having sought the consent of the participants, the research questionnaire was sent out via an internet-mediated (Survey Monkey) approach to the research sampled participants. This approach was used since the survey covers many provincial regions with wide geographical dispersion. Blaxter, *et al.,* (2006) and Creswell (2009:149) supported the use of an internet-mediated platform for a survey that covers a large geographical area to save cost and time, and other merits of the internet-mediated survey approach was exhaustively discussed in sections 4.3.1 and 5.4.3.

The research questionnaire was sent to the survey participants through Survey Monkey on 28th July 2015 and the survey was open up-until 11th September 2015. It is worthy to note that some of the respondents' emails used to send the questionnaires bounced back while some respondents opted-out. Though some of the respondents that opted-out gave reasons that they were busy and were unable to attend to the questionnaire. The reasons were contained in the response emails and telephone calls received from the respondents that opted-out. To achieve a high response rate from the participants who were willing to take part in the survey, reminders to request for their response to the survey questionnaires were made on a weekly basis to boost their interest for the research and to ensure good response (Easterby-Smith *et al*., 2012:126).

5.4.4 Qualitative Phase

Qualitative data collection mostly includes the use of open ended questionnaires, individual interviews, focus groups, direct observation, extract form diaries and case studies (Hancock, 1998; Yin, 2009:18; Easterby-Smith, *et al*., 2012:126). Qualitative researchers have documented several advantages as well as disadvantages of using a qualitative research method. The merits include, but is not limited to, facilitating an in-depth study to produce vast detailed information and a great understanding of the topic under study with a smaller number of people (Amaratunga, *et al.,* 2002:20; Easterby-Smith, *et al*., 2012:126). Open ended questions and individual interviews were employed for this research to source valuable information to complement the quantitative data, to aid the development of the affordable housing sustainability enhancement model. Consequently, interview was used to address those research questions such as; "*how does the housing financing mechanism influence affordable housing construction?"* and "*how could sustainability of affordable housing be enhanced during construction stage?"* and to reveal other parameters required in an all-inclusive sustainable housing development model.

In order to achieve an unbiased selection of participants to be interviewed, section E of the quantitative questionnaire asked the respondents whether they would consent to be interviewed for the purpose of achieving the overall objectives of this research. However, some of the respondents indicated interest while some other declined. Those respondents that indicated interest to be interviewed were contacted.

5.4.4.1 Qualitative Data Collection

Securing access for qualitative interviews is a serious concern that could frustrate the use of interview (Easterby-Smith, *et al*., 2012:126). In a research of this nature, knowing fully well the lack of readiness of construction industry professionals to participate in research survey due to the busy nature of their activities, this study thus adopts the use of a double-barrel approach when conducting a quantitative questionnaire survey as reported in the last paragraph of section 5.4.4.

Further to indication of interest by some of the survey participants, the participants were immediately contacted via a formal letter appreciating their prompt response to the quantitative survey and their readiness to be interviewed. Subsequently, interview dates were scheduled based on the availability of individual interviewees. Establishing contact with respondents immediately (as they provide the window of opportunity to be interviewed) is very essential, as is emphasised by Easterby-Smith *et al*., (2012:126):

> *''securing access may have effect on the research, once the gate keeper has shown some interest then preliminary contacts are best followed up by letter, email or telephone call. This helps fulfil credibility, may assist co-operation in the future and it provides opportunity to send further details about the research''*.

Apart from these benefits noted by Easterby-Smith, *et al*., (2012), prompt acknowledgment to survey respondents shows the level of seriousness attached to the research by the researcher, thereby promoting the respondents' interest in offering such opportunity to other researchers.

This research thus adopted semi-structured, face-to-face interviews with the respondents that indicated interest to partake in the interview based on the appointment schedule with them individually. The interview guide was structured to allow open-endedness of responses from the interviewees. This practice is encouraged for qualitative researchers because it offers the respondents an opportunity to express deep beliefs on the subject of discussions and share their experiences to generate reliable descriptions of phenomena through the interviewer's ability to facilitate trust and openness in the interviewee (Knox & Burkard 2009; Turner, 2010).

The interview guide was prepared from the preliminary analyses of quantitative data received from the respondents within the first two weeks of the quantitative data collection phase, to probe the interviewees on ''how'' the early inferences drawn through the preliminary analysis could help to achieve the specific research questions stated in section 6.4.4 of this thesis. To ensure the respondents were asked the same question and for ease of analysis, the questions were identical for each participant. The investigative questions were categorised into three sections: section A was on general information and respondent demographic data; section B was on housing financing mechanisms for affordable housing projects; and section C was on construction methods and other issues relating to construction of affordable housing. A copy of the interview guide is attached as ''Appendix D'' to this thesis.

Out of 105 responses received at the close of quantitative survey, 4 respondents indicated interest to participate in the interview, and all these respondents were contacted and interview dates was scheduled with them individually. The first interview was conducted on the 28th August 2015 with the Project Manager of a Housing Development Company A (cidb grade 7) at 14h00 at one of the company project site offices in Cape Town, and recording of the interview lasted 50 minutes. The second interview was on 3rd September 2015 with the Manager of Building Division of Construction Company B (cidb grade 9). The interview commenced at 09h00 and the recorded interview ended after 50 minutes while the entire meeting lasted 60 minutes. The interview took place at the Company B office in Cape Town, though the initial venue scheduled for the interview was Johannesburg. The third interview was on 23rd September 2015 with a Regional Project Manager in the Department of Human Settlement (DoHS) in province C between 11h00 and 12h30. The recorded interview lasted 70 minutes. The fourth interview was at the office of cidb grade 5 Construction Company D in East-London on Thursday 2nd October 2015. The interview was schedule to start at 09h00, but could not start on time due to an impromptu business meeting the interviewee, who is the Director/CEO of the company, had to attend. After about three hours of waiting, the researcher was later called in for the interview, which lasted about 50 minutes.

In all of these interviews, permission was requested from the interviewees to use digital voice recorder to record the interview and a Master Research student is always in attendance to assist the researcher in taking notes during the interview to forestall loss of information which might occur in case the voice recorder malfunctioned.

5.5 METHODS OF DATA ANALYSIS

Adopting appropriate techniques to analyse data is important to ensure that data collected from the field is correctly collated and treated to bring the research outcomes into focus. However, data for this study generally conformed to nominal ordinal scale, since most of the responses were ratings measured on a Likert scale. Therefore, both inferential and descriptive statistical techniques were used in this thesis to enhance the presentation, reliability and validity of the research results. The descriptive statistics was used to analyse the demographic and background information of the respondents and this technique includes percentile, frequencies, mean scores and charts. The inferential statistics used in this thesis include Relative Index Analysis, Analysis of Variance, Factor Analysis and Kendall Coefficient of Concordance. These techniques are discussed in the subsequent sections (5.5.1 to 5.5.6) of this thesis. To undertake all of these statistical techniques, Statistical Package for Social Sciences (SPSS) and Microsoft Excel for Windows were used.

5.5.1 Descriptive Statistics Analysis

Descriptive statistics involves the use of percentages, frequencies and mean scores for presenting descriptive findings of the survey. These techniques were generally used to analyse the data in all sections of the research questionnaire. Percentages and Frequencies was used to analyse data related to respondents' demography and background information, and the results of this analysis are presented in tables, pie charts and bar charts at the appropriate sections in this thesis.

5.5.1.1 Mean Scores

The mean scores of each variable were determined based on the 5-point Likert scale used to collect data to establish the significant factors in each of the constructs. Mean scores entail allocating a point to the respondent's ratings to the variables e.g. extremely significant equals 5 point and not significant equals 1 point, etc. Mean scores have been used extensively in researches that have similar types of variables (e.g. Assaf, *et al.,* 2010; Othman & Abdellatif, 2011; Mulliner, *et al.,* 2013 and Shackleton, *et al.,* 2014). The mean score is calculated for each construct using SPSS based on the underlying formula;

$$Mean\ score = \frac{5n5+4n4+3n3+2n2+1n1}{n5+n4+n3+n2+n1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 5.1$$

Where; n_1 *= number of respondents who answer extremely not significant*
n_2 *= number of respondents who answer not significant*
n_3 *= number of respondents who answer moderately significant*

n_4 = number of respondents who answer significant
n_5 = number of respondents who answer extremely significant

5.5.2 Relative Index Analysis

Relative index analysis was used to further analyse responses on ratings of the research variables. This technique is adjudged excellent by researchers (notably Olomolaiye, *et al.,* 1987; Adetunji, *et al.,* 2005) as a technique for aggregating the scores of variables rated on an ordinal scale by respondents. This analysis was carried out in two stages; first SPSS was used to determine the frequencies of respondents' ratings of the variable in percentages. These percentages were then imputed into equation 5.2 to calculate the variables respective Rank Indices (RI).

$$RI = \sum \frac{w}{AxN} \quad \text{……………………………….. 5.2}$$

Where; w = the weighting as assigned by each respondents on a scale of 5 to 1
A = the highest weight which is 5 in the case of this research

Therefore, based on the ranking of the RI's, the weighted average for the two groups was determined and labelled differently depending upon the context of the frequency.

5.5.3 Analysis of Variance (ANOVA)

ANOVA is a technique for testing simultaneously whether there is a significant difference between means of different populations and is best used for comparing attributes of different clusters (Fellows & Liu, 2008:205). ANOVA was employed to investigate whether the housing financing mechanism influences the choice of construction methods for housing projects, and to analyse the difference among the group means. According to Fellows and Liu (2008) ANOVA relied on the F-test (F statistics) to test whether the means of the group differs significantly. ANOVA test is employed if three conditions, such as independence, normality, and homogeneity of variance, are satisfied by the research data:

- Independence of observations: The observations that make up data are independent of one another if each observation or measurement is not influenced by any other observation or measurement (Pallant, 2010:205)
- Normality: For parametric techniques, it is assumed that the populations from which the samples are taken are normally distributed (Pallant, 2010:206). Carifio and Perla (2007:115) advise that if one is using a 5 to 7 point Likert response format, and particularly so for items that resemble a Likert scale, it is perfectly acceptable and correct to analyse the results at the (measurement) scale level using parametric

analyses techniques, such as F-Ratio or Pearson correlation coefficients or its extensions (e.g. multiple regression).

- Homogeneity of variance: For parametric techniques, an assumption is made that samples are obtained from populations of equal variances, and the test for homogeneity is performed by Levene's test for equality of variance. If the significance value is less than 0.05, it suggests that the variances for two groups are not equal, therefore, the homogeneity of variance has been violated (Pallant, 2010:206).

Therefore, the F-ratio was determined and it represents the ratio of variance between the groups by dividing it with the variance within the group. A higher F value depicts that there is more variability between the groups than within each of the groups. A lower F value below the critical indicates that the null hypothesis that states population group means are equal should be accepted.

5.5.4 Kendall Coefficient of Concordance and Chi-Square Tests

To determine the degree of agreement among the respondents in their rankings, Kendall's coefficient of concordance (W) was used. This coefficient provides a measure of agreement between respondents within a survey on a scale of zero to one, with '0' indicating no agreement and '1' indicating perfect agreement or concordance. Using the rankings by each respondent, W was computed using Equation (5.3).

$$w = 12\sum\frac{R_j^2 - 3k^2\,N(N+1)^2}{k^2N(N^2-1) - k\sum T_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \; 5.3$$

Where;

$\sum R_j^2$ is the sum of the squared sums of ranks for each of the N objects being ranked',
k is the number of sets of ranking i.e. the number of respondents, and
T_j is the correction factor required for the jth set of ranks for tied observation given by $T = \sum_{i-1}^{gj}(t_i^3 - t_i)$, where t_i is the number of tied ranks in the ith grouping of ties and g_j is the number of groups of ties in the jth set of ranks.

To verify that the degree of agreement did not occur by chance, the significance of W was tested, the null hypothesis being perfect disagreement. The Chi-square (x^2) approximation of the sampling distribution given by Equation (5.3) with (N-1) degrees of freedom is used for testing this hypothesis at a given level, for N>7 (Siegel and Castellan, 1988). The calculated x-square value, greater than its counterpart table value, implies that the W was significant at the given level of significance and as such, the null hypothesis is not supported and thus has to be rejected.

$$x^2 = k(N-1)w \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \; 5.4$$

5.5.5 Factor Analysis

The term factor analysis encompasses a variety of different related techniques. Factor analysis is used to reduce a large set of variables in a way that enables the selection of smaller sets of factors or components (Pallant, 2010181). Researchers often use factor analysis interchangeably as Principal Component Analysis (PCA). Both Factor Analysis and PCA are similar since both attempts to produce a smaller number of linear combinations of the original variables in a way that captures the variability in the pattern of correlations. The basic motivation for factor analysis is that it enable a researcher to search a fewer number of uncorrelated latent factors that will account for the inter-correlations of the response variables, so that when the latent factors are partially led out from the response variables there no longer remain any correlations between a given set of response variables (Lei, 2009:505).

Factor analysis is a multivariate statistical technique for examining the underlying structure or the structure of interrelationships (or correlations) among a large number of variables (Hair *et al.*, 1998). This approach was utilised in the work of Akadiri (2011) on sustainability. Thus, in establishing the list of criteria, it was considered important to ensure that the criteria are of adequate relevance and was independent. This analysis was performed with the assistance of SPSS Statistics v23. Kaiser-Meyer–Olkin (KMO) measure and Bartlett's Test of Sphericity were conducted to examine the sampling adequacy, ensuring that factor analysis was going to be appropriate for the research. Principal component analysis was then employed to extract groups of factors with eigenvalues greater than 1, suppressing all other factors with eigenvalues less than 1 based on Kaiser’s criterion (Pallant, 2010). To interpret the relationship between the observed variables and the latent factors more easily, the most commonly used rotation method, varimax rotation, was selected.

5.5.6 Structural Equation Model

The focus of this research is to establish models based on which affordable housing construction will be evaluated to ensure enhancement of sustainability in the construction process as well as the product. To achieve this goal, it is imperative to establish an appropriate model to evaluate a series of simultaneous hypotheses about the impacts of latent variables and manifest variables on the other variables, and consider the measurement errors. Lei (2009:495) suggests the Structural Equation Model (SEM) as a veritable statistical tool to accomplish the aforementioned task.

The standard SEM is composed of two components. The first component is a confirmatory factor analysis model, which relates the latent variables to all their corresponding manifest variables (indicators) and takes the measurement errors into account. This component can be regarded as a regression model, which regresses the manifest variables with a small number of latent variables. The second component is again a regression type structural equation, which regresses the endogenous (dependent) latent variables with the linear terms of some endogenous and exogenous (independent) latent variables (Lei, 2009:496 and Hoyle, 2012:6). As latent variables are random, they cannot be directly analysed by techniques in ordinary regression that are based on raw observations. However, conceptually, SEMs are formulated by the familiar regression type model, application of which is predicated on some basic assumptions upon which the interpretation of the model will be verified.

5.5.6.1 Assumptions in SEM

In construction management research, it is important to make certain assumptions about the data to guide accurate interpretation of the model developed through the analysis of data. Statistical tests using Multiple Regression (MR) generally assume that the residual are normally distributed and have uniform variances across all levels of the predictors (Klien, 2012:111), a standard regression analysis assumes a linear relationship only. Conversely, the assumption underlining ANOVA are: normal population distribution, homogeneity of variance and equal and uncorrelated error factors. It is to be noted that any departure from these assumptions will seriously bias the outcomes of the F-test and T-test.

For SEM, Klien (2012:113) outlines five basic assumptions; (a) the presumed cause (e.g. X) must occur before the effect (e.g. Y) (b) that there is association or an observed covariation between X and Y, (c) there is isolation, which means that there are no other plausible explanations of the covariation between X and Y, (d) that the observed distributions match those assumed by the method used to estimate associations, and (e) the direction of causal relation is correctly specified that X indeed causes Y, or X and Y cause each other in a reciprocal manner. It is essential to establish in SEM a temporal precedence between the variables.

5.6 Chapter Summary

This chapter presents the research methods used in this thesis. The methodological underpinning of the research, including the philosophical stance of the research and various approaches used for data collection, were exhaustively explained. The study adopts a mixed method technique and collected data using a quantitative questionnaire for the quantitative phase and a structured interview for the qualitative strand. It was indicated that descriptive statistical techniques, Principal Component Analysis (PCA), amongst other statistical techniques, was be used for analysis of the quantitative questionnaire survey. Structural Equation Modeling (SEM) was used for the housing sustainability enhancement model. The next chapter presents the quantitative data, data analysis and a discussion of the findings.

CHAPTER SIX
DATA ANALYSIS AND DISCUSSIONS

6.1 INTRODUCTION

This chapter is subdivided into various sections to present the data compiled from the questionnaire survey response. The quantitative data was analysed using both descriptive and inferential statistical techniques, and inferences drawn from the analysis was used to validate the research conceptual framework. The respondent background information was summarised using descriptive statistics, and responses to other questions related to the research constructs were analysed using inferential statistical methods as discussed in Chapter five of this thesis. The analysis of the following research constructs are presented in this chapter: (i) sustainability awareness in building design and construction, (ii) identification of financing mechanism for affordable housing construction, (iii) identification of factors affecting housing cost, (iv) housing stakeholder satisfaction criteria, (v) factors influencing choice of construction method for sustainable housing and (vi) social sustainability criteria for affordable housing construction. These analyses were undertaken as a preamble to the development of the affordable sustainable housing construction model that is presented in chapter eight.

6.2 ANALYSIS OF RESPONDENTS' DEMOGRAPHIC INFORMATION

The survey respondents in this study were drawn from; general building contractors who are registered on grade 3 – 9 on the cidb register and who are based in all nine provinces of South Africa, all practicing architects who are registered with the South African Council for Architect profession (SACAP), and selected employees of the Department of Human Settlement (DoHS) in all nine provinces of South Africa.

6.2.1 Respondents Organisation Profile

The profile of organisations with which the respondents are affiliated is presented in Table 6.1 and Table 6.2. The results of frequency analysis presented on Table 6.1 captured the; type of organisation, types of building projects executed by the organisation, regular clients of the organisation and the province wherein the company operates in RSA. Table 6.2 present the results of frequency analysis on background information peculiar to the respondent within their organisation and their personal professional career.

Table 6. 1 Summary of respondent organisation demographic information

Variable	Frequency	Percentage
Type of organisation		
Architect & Design firm	38	36.19%
Building Contractor	53	50.48%
Government agency (Department of Human Settlements)	5	4.76%
Others	9	8.57%
Type of building project executed		
Residential	76	73.8%
Commercial	62	60.2%
Institutional	43	41.7%
Industrial	40	38.8%
Organisation regular client		
Public sector	59	57.8%
Private sector	53	52%
Private client	52	51%
Province where the organisation operates		
Eastern Cape	14	13.6%
Free State	10	9.7%
Gauteng	32	31.1%
KwaZulu-Natal	23	21.9%
Limpopo	8	7.8%
Mpumalanga	7	6.8%
Northern Cape	4	3.9%
North West	5	4.76%
Western Cape	29	27.62%
Indication of organisation size (cidb grading)		
Government employee	6	5.7%
Grade 2	9	8.6%
Grade 3	33	31.4%
Grade 4	12	11.4%
Grade 5	15	14.3%
Grade 6	22	21%
Grade 7	4	3.8%
Grade 8	2	1.9%
Grade 9	2	1.9%

6.2.1.1 Nature of Organisation

Analysis of data retrieved from the survey questionnaire shows that approximately 36% of the respondents were architects who are working with private architectural and design firms. Fifty per cent (50%) of the respondents were professionals in the construction industry who have different training but are working with building contracting firms. More so, approximately 5% work with the Department of Human Settlement (DoHS), i.e. the government department that is saddled with the responsibility of providing affordable housing for the RSA population, while approximately 9% work in other organisations, such as civil contractors, electrical services companies, building materials manufacturers and suppliers. However, all of these companies denoted as ‘others’ form part of the construction team on mass-housing projects. The outlooks of the results in Table 6.1 have shown that the geographical spread of the respondents within the building construction industry can be adjudged impeccable, thus has a great credibility on the research data.

6.2.1.2 Types of Building Project Executed and Regular Client

While assessing the type of building project executed by respondents’ companies, respondents were provided with the opportunity to indicate all types of building their company undertakes. The results of analysis in Table 6.1 thus showed that approximately 74% undertake residential building, 60% undertake commercial building, 42% undertake institutional buildings and 39% undertake industrial buildings. From this result, it is evident that majority of the respondents undertook residential building, which is an indication that the data provided by the respondents in their survey response could be relied upon in making decisions on affordable housing construction.

On the company regular clientele, the results of analysis (Table 6.1) showed that 58% of the respondents’ organisations work for public clients (government agencies), 52% work for the private sector i.e. private companies other than government agencies, and 51% work for private clients. Private clients are individuals who engaged the services of building contractors, architects and other professionals in the construction of their home.

6.2.1.3 Organisation Operational Base

This research is conceptualised to cover the entire South Africa, hence the need for a geographical operational base of the respondents. The frequency analysis showed that 14% of the respondents have offices in the Eastern Cape, 10% have offices in the Free State, 31% operate in the Gauteng Province, 22% operate in KwaZulu-Natal, 8% practice in the Limpopo Province, 7% have offices in Mpumalanga, 4% in the Northern Cape, approximately 5% in North-West Province and 28% have offices in the Western Cape. The results have shown that majority of construction professionals have offices in Gauteng, KwaZulu-Natal and the Western Cape. This is unconnected to the fact that these three provinces are the largest provinces in South Africa and that a large volume of construction works are being executed in these provinces. Also the analysis has shown that a reasonable percentage of construction professionals who have their practice offices in other provinces participated in the survey, thereby making the result of analysis from the survey data generalisable within RSA and developing countries in general, since most of the companies do undertake building projects in most neighbouring countries around RSA.

6.2.1.4 Size of Organisation

Size of organisation was determined based on the organisation rating on the cidb grade, though the cidb grade did not apply to the government agency (DoHS). On Table 6.1 approximately 6% of the respondents are government employees (staff of DoHS), 9% of the respondents' organisations are cidb grade 2 organisations, grade 3 organisations are 31%, grade 4 organisations are approximately 11%, grade 5 organisations are 14%, grade 6 organisations are 21%, grade 7 organisations are 4% and grade 8 and 9 organisations are approximately 2% each. The results of analysis have shown that the majority of architectural design firms and building contractors have their organisations registered within grade 3 to grade 6 of cidb grading. However, small to medium size organisations are mostly involved in construction of affordable housing, and their expertise in a research to assess sustainability in affordable housing construction is highly essential.

6.2.2 Respondents Background

Table 6.2 presents the results of analysis on data relating to personally to the respondents. The results of descriptive statistics show that 18% of the respondents were Directors/CEOs in their organisations, approximately 49% were Managers, 12% were Principal/Senior Architects, approximately 11% were architect technologists and 11% were project engineers. This result has shown that the respondents' representations were from people with adequate experience whose judgements and information provided could be considered reliable.

On the professional affiliation of respondents, the results reveal 35% of the respondents to be affiliates of SACPCMP, 29% are registered members of SACAP, 10% were members of SACQSP, 7% were members of SACCEP, approximately 14% were registered members of SAIAT and approximately 6% were affiliates of CIOB. Thus, the respondents' professional affiliation to registered bodies attests to their experience and to the credibility of the information that they have provided.

Analysis on respondents' working experience showed that an overwhelming 54% have above 20 years working experience, while approximately 46% have working experience ranging between 6 to 20 years. These results proved further that the respondents were qualified, competent and highly experienced and that their expertise on sustainable building design and construction is not in doubt.

Table 6. 2 Respondent background information

Variable	Frequency	Percentage
Respondent position		
Director	19	18.1%
Manager	51	48.6%
Principal / Senior Architect	13	12.4%
Architect Technologist	11	10.5%
Project Engineer	11	10.5%
Professional affiliation		
SACPCMP	37	35.2%
SACAP	30	28.6%
SACQSP	10	9.5%
SACCEP	7	6.7%
SAIAT	15	14.3%
CIOB	6	5.7%
Years of working experience		
0 - 5 years	0	0
6 -10 years	2	1.9%
11 - 15 years	11	10.5%
16 - 20 years	35	33.3%
above 20 years	57	54.3%

6.3 SUSTAINABLE CONSTRUCTION IMPLEMENTATION IN AFFORDABLE HOUSING CONSTRUCTION

6.3.1 Awareness of Environmental Impacts on Building Design and Construction

One of the purposes of this survey is to identify environmental factors mitigating affordable housing construction. To achieve this purpose, the need to assess the level of awareness of the study's stakeholders on sustainable building design and construction is essential. However, survey data on the research stakeholder awareness on environmental impacts during design and construction were analysed using descriptive statistics and presented in Table 6.3. The results of analysis in Table 6.3 and Figure 6.1 showed that approximately 38% of the research stakeholders are extremely aware of the effects on the environment during building design, 35% are moderately aware, 17% are somewhat aware, approximately 7% are slightly aware and 3% are not aware of environmental impacts on building projects at design stage. Consequently, approximately 90% of the respondents are well informed on the implications of building design to depletions of natural resources and its attendant effects on the environment.

On environmental awareness at construction stage, the research stakeholders indicated that they were adequately informed on the environmental concerns at the construction stage of building projects. This is attested to by approximately 42%, 36% and 11% of the respondents who were extremely aware, moderately aware and somewhat aware, respectively. While approximately 10% are slightly aware and 1% are not aware of environmental concerns at construction stage of building. The results presented in Table 6.3 and Figure 6.2 put the total number of the respondents who are well informed to be 89% of the entire research respondents.

The growing awareness on environmental issues in sustainable construction has placed much responsibility on construction stakeholders to design, construct and manage building projects in a manner that minimises negative treatment of the environment (Abidin, Yusof & Othman, 2013:10). In the same vein, Du Plessis (2007) advocated that stakeholders must be adequately informed of the enablers that are vital towards ensuring the construction sector is able to respond to the demands of sustainable building construction. Gibberd (2009:1123), while analysing the provisions of the South African Constitution on sustainable buildings, noted that the built environment professionals must be courteous of the environment when undertaking all developmental projects to actualise the RSA constitutional provisions on sustainable building construction. Consequently, RSA construction stakeholders have improved their environmental consciousness, thus giving rise to high responsiveness to environmental concerns on construction projects. Thus, the results confirm the proposition: *"environmental consideration is important in affordable housing design and construction"*.

Table 6. 3 Summary of respondent's awareness on environment in building projects

Variable	Frequency	Percentage
Environmental awareness at design stage		
Not aware	3	2.9%
Slightly aware	7	6.7%
Somewhat aware	18	17.1%
Moderately aware	37	35.2%
Extremely aware	40	38.1%
Environmental awareness during construction		
Not aware	1	1%
Slightly aware	10	9.5%
Somewhat aware	12	11.4%
Moderately aware	38	36.2%
Extremely aware	44	41.9%

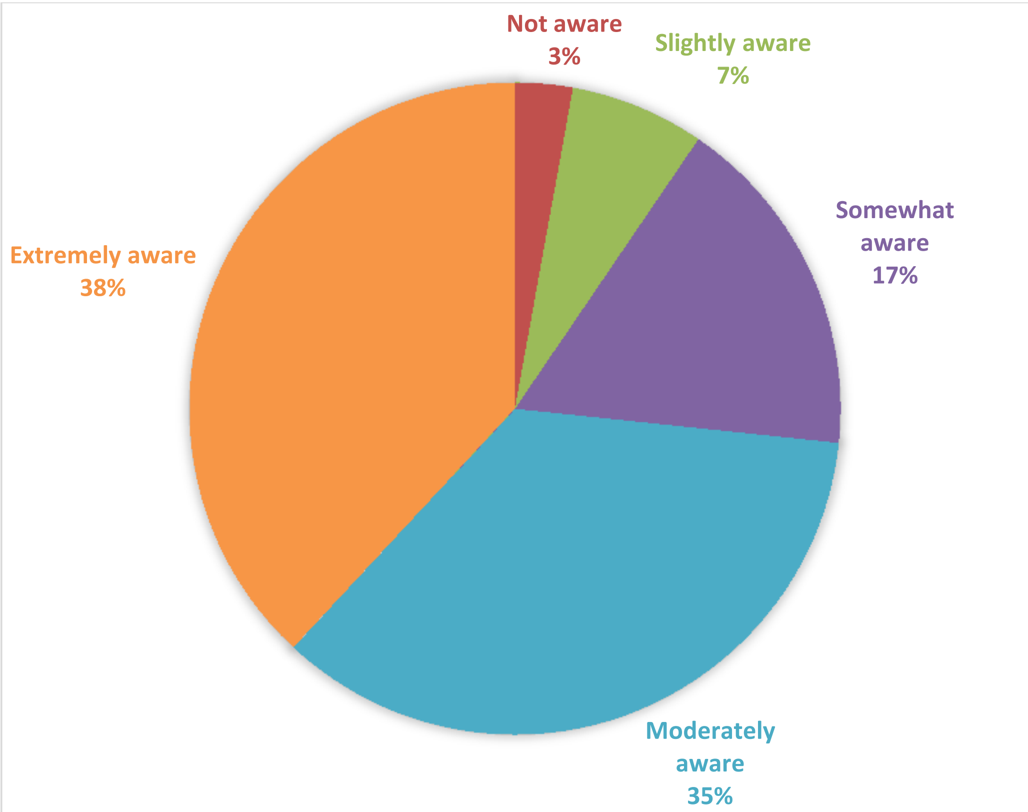

Figure 6. 1: Environmental awareness at design stage of building

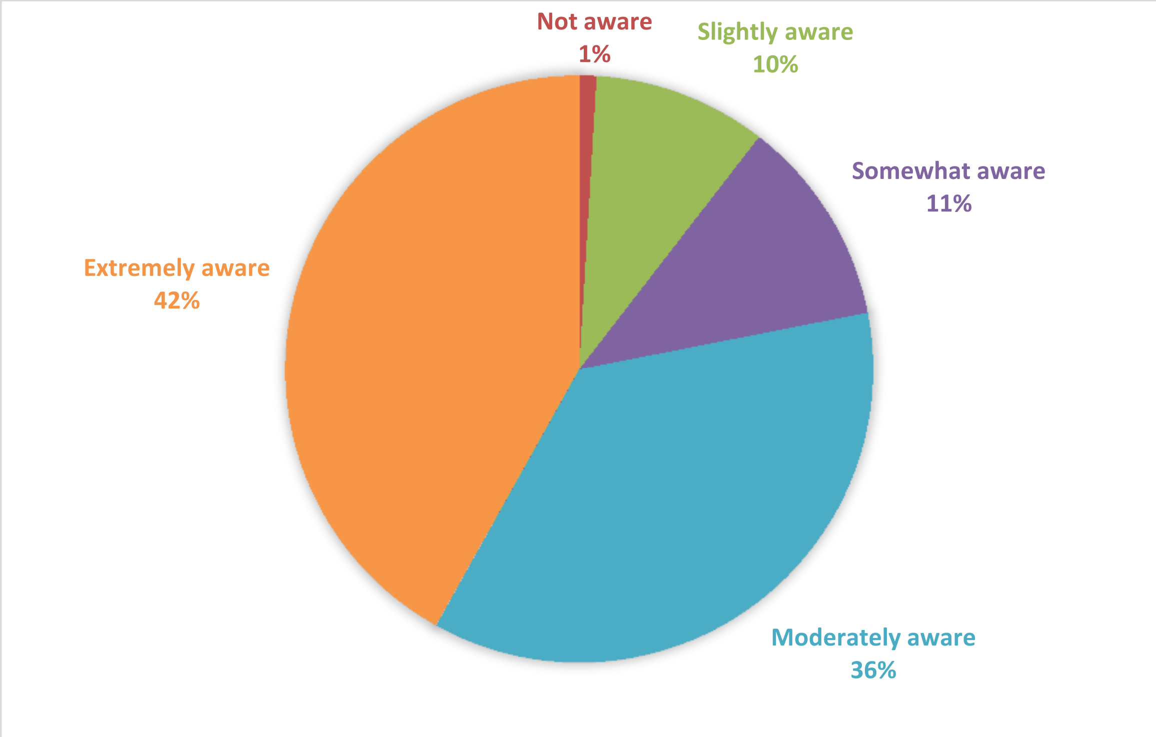

Figure 6. 2: Environmental awareness at construction stage

6.3.2 Environmental Sustainability Concern on Construction Projects

As a means to evaluate the environmental factors guiding construction professionals in the design and construction of buildings, the research stakeholders were asked to give their views on identified environmental factors. The responses were first subjected to reliability analysis using *"Cronbach's Alpha"*, the results presented in Table 6.4 shows very high internal consistency in the scale with all the variables having above 0.85 Cronbach alpha value.

Table 6. 4 Cronbach’s Alpha reliability test statistics on environmental factors

Factors	Scale Mean	Scale Variance	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha value
Population growth	45.95	45.55	.430	.395	.872
Understanding environmental impact at inception stage	45.89	44.64	.534	.447	.866
Desertification	46.32	43.20	.534	.520	.866
Environmental assessment is important consideration	45.90	45.22	.532	.415	.867
Negative treat to environment	46.11	41.99	.613	.521	.861
Depletion of renewable resources	46.03	43.86	.558	.387	.865
Depletion of non-renewable resources	46.4	42.17	.543	.442	.866
Global warming	46.03	43.26	.596	.561	.863
Deforestation	46.10	42.08	.611	.543	.861
Water pollution	45.88	41.96	.706	.832	.856
Air pollution	45.99	41.3	.746	.808	.853
Destruction of historical buildings	46.53	40.75	.487	.407	.875

In addition to the internal consistency exhibited in the data based on the results of Cronbach’s alpha reliability statistics, descriptive statistics were employed due to the nature of the data, the ease with which it can determine, explain and be used in other computations (Ankrah, 2007 and Oyewobi, 2014). Table 6.5 and Table 6.6 shows that the biggest concerns for the construction industry as regards its activities on the environment are water pollution, population growth, air pollution, depletion of renewable resources, global warming and deforestation; while desertification, depletion of non-renewable resources and destruction of historical buildings were least ranked factors. Previous studies, such as Ding’s (2004), concur that water pollution is the greatest nightmare for the construction industry as regards its activities on the environment. Ding (2004) expresses that the run-off water from building construction sites is one of the main polluters of underground water and rivers, and dust generated from construction activities also degrades the outdoor air quality which affects people living in the surrounding area. Manufacturing of building materials and construction activities are also water intensive and also lead to hazardous contamination through toxic waste (du Plessis, 2007). Similarly, the results of descriptive statistics have identified depletion of renewable resources, global warming and deforestation as significant impacts of construction on the environment. This result is consistent with findings of Ding (2004) and Akadiri (2011).

Table 6. 5 Descriptive statistics for environmental concern in building construction

Coding	Environmental Concern	Minimum	Maximum	Mean	Std error	Std deviation
	Environmental impact factors					
ENVC7	Water pollution	1.00	5.00	4.4095	.0841	.8626
ENVC1	Population growth	2.00	5.00	4.3333	.0749	.76795
ENVC8	Air pollution	1.00	5.00	4.2952	.0865	.8871
ENVC3	Depletion of renewable resources	2.00	5.00	4.2571	.0801	.8207
ENVC5	Global warming	2.00	5.00	4.2571	.0823	.8438
ENVC6	Deforestation	1.00	5.00	4.1810	.0935	.9585
ENVC2	Desertification	1.00	5.00	3.9619	.0907	.9294
ENVC4	Depletion of non-renewable resources	1.00	5.00	3.8857	.1015	1.0406
ENVC9	Destruction of historical buildings	1.00	5.00	3.7524	.1275	1.3066
	Strategy to mitigate construction impact					
ENVCS1	Understanding environmental impact at inception stage	2.00	5.00	4.4000	.0736	.7544
ENVCS2	Environmental assessment is important consideration	2.00	5.00	4.3810	.0668	.6847
ENVCS3	Negative treat to environment	1.00	5.00	4.1714	.0942	.9653

Table 6. 6 Frequency of response on environmental concern in construction industry

Coding	Factors	Extremely not important	Not important	Indifferent	Important	Very important	Mean score	Rank
	Environmental impact factors							
ENVC7	Water pollution	2.9%	0	7.6%	32.4%	57.1%	4.4095	1
ENVC1	Population growth	0	3.8%	6.7%	41.9%	47.6%	4.3333	2
ENVC8	Air pollution	1.9%	1.9%	11.4%	34.3%	50.5%	4.2952	3
ENVC3	Depletion of renewable resources	0	1.9%	18.1%	32.4%	47.6%	4.2571	4
ENVC5	Global warming	0	4.8%	11.4%	37.1%	46.7%	4.2571	5
ENVC6	Deforestation	1%	7.6%	9.5%	36.2%	45.7%	4.1810	6
ENVC2	Desertification	1%	5.7%	21.9%	39%	32.4%	3.9619	7
ENVC4	Depletion of non-renewable resources	1%	9.5%	25.7%	27.6%	36.2%	3.8857	8
ENVC9	Destruction of historical buildings	3.8%	21%	14.3%	18.1%	42.9%	3.7524	9
	Strategy to mitigate construction impact							
ENVCS1	Understanding environmental impact at inception stage	0	2.9%	7.6%	36.2%	53.3%	4.4000	1
ENVCS2	Environmental assessment is important consideration	0	1%	8.6%	41.9%	48.6%	4.3810	2
ENVCS3	Negative treat to environment	4.8%	1%	7.6%	45.7%	41%	4.1714	3

As indicated in the results on Table 6.5 and Table 6.6, population growth is ranked the second most significant concern for the construction industry, relating to the impact of its activities on the environment. It is worthy to note that as population increases, so the demand on the construction industry increases for the provision of buildings and supporting infrastructure to ensure a healthy living for the people. Du Plessis (2007:13) notes that the rapid population growth has an attendant implication for natural resources, most especially in the case of housing and infrastructure construction, but the desire of the construction industry must be the realisation of its enormous demand with less impact on global resources.

Therefore, it is important to seek expert opinions on ways through which adverse effects of construction activities on the environment can be mitigated. The results of descriptive analysis in Table 6.5 and Table 6.6 show that for construction organisations to be responsive to the environment, understanding the environmental impact at the inception stage is most significant, followed by an environmental assessment of all construction projects at the conceptual stage. This result is in line with the findings of other authors (notably Ding, 2004; Ding, 2008; Akadiri & Fadiya, 2013), that environmental issues are significant and they should be made a mandatory requirement at the conceptual stage of building projects. Buttressing this, Elhag and Boussabaine (2001) explained that the significance of the consideration of sustainability early in a project life cycle could result in a decrease in capital costs as compared to projects in which environmental assessments were considered at a later stage.

6.3.3 Practice of Sustainability in Building Development in RSA

Table 6.7 displays the results of respondent assessments of their adoption of sustainability concepts in housing development. Four questions were presented before the research stakeholders to assess how they fare in practice of sustainability.

The respondents' knowledge on sustainability was put to test, the results revealed that approximately 4% of the respondents do not have any knowledge on sustainability, 51% indicated having insufficient knowledge, 2% of the respondents have sufficient knowledge, while approximately 34% and 10% of the respondents have good and excellent knowledge respectively. Summarily, this assessment shows that majority of the respondents, about 55% have little knowledge on sustainability practices in building development and approximately 44% have a good understanding of sustainability.

To further assess respondents' competency in sustainability, their level of familiarity with sustainable building materials specification was sought, and the results showed that approximately 4% were not familiar, 8% slightly familiar, 38% are somewhat familiar, while 36% and 14% were moderately and extremely familiar respectively. The overall results shows that approximately 50% are well familiar with sustainable building materials specification, while about 40% are somewhat familiar with sustainable building materials specification.

Moving forward from the above revelations, 79% of the respondents indicated that adequate consideration is given to sustainability in selection of building materials and 21% of the respondents indicated that building materials is selected for their projects without consideration for sustainability. Moreover, having assessed the competency, familiarity and consideration for sustainability in building materials specification and selection, it is incumbent to assess their level of implementation of sustainability in their projects. The results on their level of implementation thus show that approximately 69% of the respondents implement sustainability in their building projects.

Table 6. 7 Practice of sustainability concept in building development

Rating scale	Frequency	Percent	Valid Percent	Cumulative Percent
Assessment of respondents knowledge on sustainability				
don't know	4	3.8	3.8	3.8
Insufficient	53	50.5	50.5	54.3
Sufficient	2	1.9	1.9	56.2
Good	36	34.3	34.3	90.5
excellent	10	9.5	9.5	100
Total	**105**	**100**	**100**	
Familiarity with sustainable building material specification				
not at all	4	3.8	3.8	3.8
slightly familiar	8	7.6	7.6	11.4
somewhat familiar	40	38.1	38.1	49.5
moderately familiar	38	36.2	36.2	85.7
extremely familiar	15	14.3	14.3	100
Total	**105**	**100**	**100**	
Consideration for sustainability when selecting building materials				
No	22	21.	21	21
Yes	83	79	79	100
Total	**105**	**100**	**100**	
Previous project executed using sustainability concepts				
less than 10%	33	31.4	31.4	31.4
11 - 20%	17	16.2	16.2	47.6
21 - 30%	16	15.2	15.2	62.9
31 - 40%	10	9.5	9.5	72.4
above 40%	29	27.6	27.6	100
Total	**105**	**100**	**100**	

6.4 CONSTRUCTION CONSTRAINTS TOWARDS ACHIEVING USER'S SATISFACTION IN SUSTAINABLE HOUSING

The cardinal objective of this research is to develop a model through which affordable housing construction could be assessed to enhance sustainability of the housing product. However, a number of variables were identified from literatures as variables mitigating achievement of user satisfaction in adopting sustainability in construction of affordable housing for the poor population. Housing satisfaction is an important factor in a model to enhance sustainability in housing, amongst other factors; both descriptive statistics and factor analysis were employed for analysing the survey data on user satisfaction.

6.4.1 Ranking of Constraints to Achieve User Requirements in Housing Construction

Results of descriptive statistical analysis on variables mitigating the achievement of user satisfaction in housing construction are displayed in Table 6.8 and Table 6.9, which shows that 'budget constraints' having a mean-score value of 4.4095 is ranked the most significant variable mitigating achievement of user satisfaction in housing construction. The highest mean score exhibited by budget constraint is attested by approximately 91% of the respondents that perceived the variable as a significant constraint to achievement of user requirements in housing construction. It is worthy to note that this result is corroborated by (Assaf, *et al.,* 2010; Sullivan & Ward, 2012; Aigbavboa, 2013), that governments are responsible for restraints with budgetary provision for affordable housing construction in developing countries. Since the major constraint on meeting housing needs is the low incomes of the economically weaker sectors of urban society, their incomes form the basis upon which budgetary provision for affordable housing is benchmarked (Choguill, 2007:149). Sullivan and Ward (2012:314) assert that housing for the low-income population requires careful consideration of the feasibility, cost and potential benefits of specific technologies in the particular context, hence the inability of housing development agencies to adopt sustainability in low-income housing construction.

Respondents also attached high significance to 'cost of eco-friendly building materials' as a constraint to the achievement of user satisfaction and enhancement of sustainability in affordable housing. The results show that 81% of the research stakeholders attested to the high significance of this variable, thus having a mean-score value of 4.0762 and it is ranked as the second most significant variable. This perception is unconnected with the view of Wallbaum, *et al*., (2012), that the most promising technology to achieve sustainable housing construction is through the use of local building materials to maximise the potentials of available construction materials and techniques. Furthermore, the third ranked variable is 'use of energy saving appliances' with a mean-score value of 3.9327 and rated by approximately 82% of the respondents as a significant variable.

Household size is ranked as the fourth variable that mitigates the achievement of user satisfaction in affordable housing construction by government in South Africa. This variable has a mean-score value of 3.9048 and is perceived by over 70% of the respondents as a significant variable. Household size has been perceived by most commentators on affordable housing (Sullivan & Ward, 2012:313) who majorly relate household income to housing affordability. Given that 50 years of housing policy development has not solved this problem and since the number of people in inadequate housing in the developing world increases each year, there is little reason to believe that just because we label something 'sustainable' it will be any more successful.

The survey results also showed that use of water saving, sanitary and plumbing appliances ranked fifth and lack of access to relevant information on availability of sustainable building materials ranked sixth. This ranking resulted from the mean-score values of 3.8571 and 3.7048 exhibited by these variables. More so, approximately 68% and 59% of the respondents rate the variables as significant constraints to achieving user requirements in affordable housing development amongst other variables.

Table 6. 8 Mean statistics of constraints to achieve user satisfaction in housing development

Coding	Environmental Concern	Minimum	Maximum	Mean	Std error	Std deviation	Rank
HSF1	Budget constraints	2.00	5.00	4.4095	.0686	.7029	1
HSF2	Cost of eco-friendly Building materials	2.00	5.00	4.0762	.0785	.8049	2
HSF8	Energy savings electrical appliance	2.00	5.00	3.9327	.0776	.7915	3
HSF6	Household Size	2.00	5.00	3.9048	.0872	.8936	4
HSF11	Water savings sanitary and Plumbing appliances	2.00	5.00	3.8571	.0838	.8596	5
HSF5	Lack of access to relevant information on availability of sustainable materials	1.00	5.00	3.7048	.0876	.8979	6
HSF3	Lots of time and man power in analysing and selection of construction materials	2.00	5.00	3.6857	.0890	.9126	7
HSF13	Building forms	1.00	5.00	3.6857	.0837	.8583	8
HSF4	Building aesthetics	2.00	5.00	3.6476	.0947	.9705	9
HSF7	Building users access to medical facilities	1.00	5.00	3.4095	.0924	.9476	10
HSF9	Sustainability Building Materials not aesthetically pleasing	1.00	5.00	3.3619	.0958	.9817	11
HSF12	Neighbourhood socio economic status	1.00	5.00	3.3238	.1078	1.1050	12
HSF10	Privacy from neighbours	1.00	5.00	3.2667	.1033	1.0585	13

Table 6. 9 Frequency of respondents' perception on user satisfaction variables

Coding	Variable	extremely not significant	not significant	indifferent	significant	extremely significant	Mean score
HSF1	Budget constraints	0	1.9%	6.7%	40%	51.4%	4.4095
HSF2	Cost of eco-friendly Building materials	0	4.8%	14.3%	49.5%	31.4%	4.0762
HSF8	Energy savings electrical appliance	0	3.8%	22.9%	48.6%	33.8%	3.9327
HSF6	Household Size	0	8.6%	19%	45.7%	26.7%	3.9048
HSF11	Water savings sanitary and Plumbing appliances	0	6.7%	24.8%	44.8%	23.8%	3.8571
HSF5	Lack of access to relevant information on availability of sustainable materials	1%	6.7%	33.3%	39%	20%	3.7048
HSF3	Lots of time and man power in analysing and selection of construction materials	0	10.5%	30.5%	39%	20%	3.6857
HSF13	Building forms	1%	5.7%	34.3%	41.9%	17.1%	3.6857
HSF4	Building aesthetics	0	14.3%	27.6%	37.1%	21%	3.6476
HSF7	Building users access to medical facilities	1%	14.3%	42.9%	26.7%	15.2%	3.4095
HSF9	Sustainability Building Materials not aesthetically pleasing	1.9%	20%	28.6%	39%	10.5	3.3619
HSF12	Neighbourhood socio economic status	1.9%	26.7%	25.7%	28.6%	17.1%	3.3238
HSF10	Privacy from neighbours	1%	27.6%	30.5%	25.7%	15.2%	3.2667

6.4.2 Identifying the Underlying Factors to Achieve User Requirement in Affordable Housing

In order to ascertain the underlying structure to achieve user requirements in housing development amidst other mitigating circumstances, Principal Component Analysis (PCA) was performed, to reduce and further classify the variables for model development. PCA is an integral technique under "Factor Analysis" though PCA is often used interchangeably with FA by many researchers, since both techniques attempt to produce a smaller number of linear combinations of the original variables in a way that captures the variability in the patter of correlations within the variables (Pallant, 2011:182). However, both PCA and FA often produce similar results, but review by Tabachnick and Fidell (2012:639) gave a clear distinction between PCA and FA. Tabachnick and Fidell (2012:640) conclude that *"if a researcher's interest is in a theoretical solution uncontaminated by unique and error variability …. Factor Analysis (FA) is the answer, if on the other hand, interest is on simply empirical summary of the data set, Principal Component Analysis (PCA) is the answer"*. Therefore, going forward form Tabachnick and Fidell's distinction, PCA is used, since the interest of this research is to produce an empirical summary of the data set.

Authors on factor analysis and principal component analysis have argued that sample size for PCA is a large sample size. Cattell (1978) suggests that 500 observations is a good sample size to use by researchers for PCA, though Cattell reiterated that a 200 – 250 sample could be acceptable. MacCallum, Widaman, Zhang and Hong (1999) posit that samples in the range of 100 - 200 are acceptable with well determined factors. Also, Tabachnick and Fidell (2012:618) contend that sample size in the range of 100 - 200 is acceptable for PCA. The authors (Tabachnick & Fidell (2012) stressed further that samples well below 100 are acceptable, although caution that such small samples may run the computational risk of failure of the solution to converge. More so, Hair et al. (2010), after careful analysis on small samples for PCA, concur that a sample size of 50 is well acceptable but with 0.75 factor loading, while Field (2013) contends that sample size less than 100 with commonality greater than 0.6 is perfectly acceptable.

Consequently, it is clear that there is no acceptable sample size for PCA, however, the sample size for this study is 105, which is above 50, as opined by (Hair, et al. 2010; Field, 2013) as the minimum sample size. Also, evidences are abound in construction management literature where exploratory FA and PCA was performed on analyses with less than 72 samples (Kaming, Olomolaiye, Holt & Haris, 1997; Ankrah, 2007; Oyewobi, 2014). Therefore the question of whether PCA can be performed or sample size in adequacy may not arise.

6.4.2.1 K.M.O. Adequacy and Bartlett's Sphericity Test

The first step in PCA analysis is to test the appropriateness of a study's data for PCA analysis (Pallant, 2012:192), hence the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's test of Sphericity were used for the identified constraints to achieve user satisfaction in affordable housing construction. Table 6.10 shows the results of KMO and Bartlett's test of Sphericity. These tests provide the basis for measuring the minimum standard that the data must meet before being considered adequate for further analysis. The KMO index ranges from 0 to 1, with 0.6 suggested as the minimum value for a good factor analysis (Pallant, 2012; Tabachnick & Fidell, 2012). The Bartlett's test of Sphericity indicates the strength of the relationship among variables and it should be significant at $p<0.05$ for the PCA to be considered appropriate (Pallant, 2012; Tabachnick & Fidell, 2012). However, the results on Table 6.10 display KMO value of 0.868 which is greater than 0.6 and less than 1, while the Bartlett's Sphericity value $p = 0.000$ (i.e. $p<.5$). Therefore, the data is adequate and suitable to be used for PCA.

Table 6. 10 Results of data adequacy and suitability test on user satisfaction variables

Test		Value	Remark
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.868	Significant and adequate for PCA
Bartlett's Test of Sphericity	Approx. Chi-Square	598.890	
	df	78	
	Sig. (p< .5)	.000	Significant and suitable for PCA

6.4.2.2 Principal Components Factors Underlying User Satisfaction

According to Pallant (2012), the next step after showing the appropriateness and suitability of the research data is component (factor) extraction. This is a process to ascertain the number of components to retain, based on their contribution to the construct, since not all factors are kept (Tabachnick & Fidell, 2012). The most commonly used methods of factor extraction in PCA include: Kaiser's criterion; the using eigenvalue greater than 1 rule; Catell's scree test; retaining all factors above the elbow in the structure and Horn's parallel analysis; comparing the eigenvalue with those randomly generated from a data set of the same size (Pallant, 2012:184).

In this thesis, "Kaiser's criterion using eigenvalues" was adopted to extract the components and varimax rotation was used to extract the variables that load on each identifiable component. However, the significant factors, according to Kaiser's criterion, are those factors with eigenvalues above 1. In Table 6.11, two components with initial eigenvalues of greater than 1 were extracted from the constraints to achieve user satisfaction in housing construction variables. The eigenvalues of the two components extracted is 5.801 and 1.365; the result shows that the first component is capable of explaining 44.62% of the variance while the second component explained 10.5% of the variance. However, the two components combined to explain 55.12% of the total variance.

Table 6. 11 Total variance explained by the components

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5.801	44.622	44.622	5.801	44.622	44.622	5.161
2	1.365	10.503	55.125	1.365	10.503	55.125	3.724
3	.969	7.457	62.583				
4	.872	6.710	69.293				
5	.749	5.758	75.052				
6	.645	4.965	80.017				
7	.568	4.372	84.389				
8	.470	3.613	88.001				
9	.441	3.390	91.392				
10	.346	2.661	94.052				
11	.307	2.358	96.411				
12	.242	1.859	98.270				
13	.225	1.730	100.000				

To further confirm the number of components to retain, Catell's scree test was performed on the variable and the results in Figure 6.3 (scree plot) shows that two components are retained. These components are the point, which is above the elbow on the scree plot shown in Figure 6.3. These components, however, contribute the most to the variance in the data set, and this agrees with the results displayed in Table 6.11.

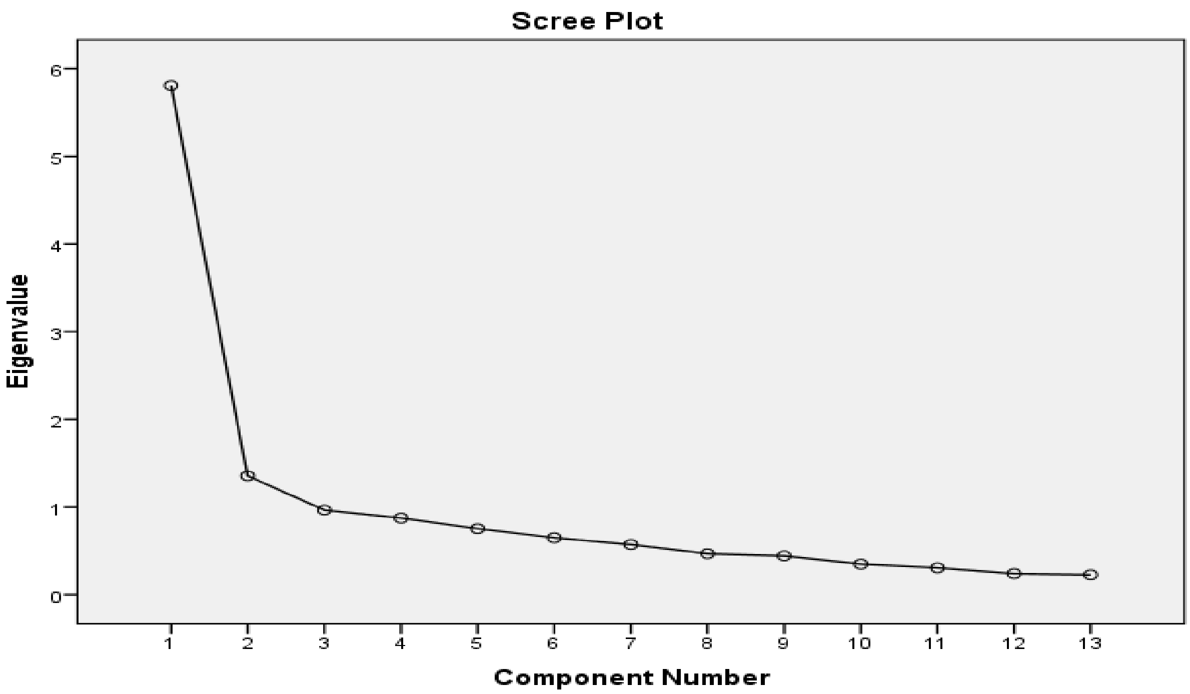

Figure 6. 3: Catell's scree plot for user satisfaction in housing

Furthermore, Pallant (2012) and Tabachnick & Fidell, (2012) suggested a further confirmatory test using “Parallel analysis” before taking a decision on the number of components to be retained. Parallel analysis involves comparing the size of the eigenvalues with those obtained through a randomly generated data set using the ‘MonteCarloPA application package’. It is worthy to note that parallel analysis has been adjudged the most appropriate technique to identify the correct number of components to retain (Pallant, 2012; Tabachnick & Fidell, 2012). Although, the authors cautioned the results of parallel analysis be interpreted amidst Kaiser’s criterion and Catell’s scree test to determine the number of components to be retained. The criterion eigenvalue of component 1 and component 2 is 5.801 and 1.365 respectively (see Table 6.11), while the corresponding random eigenvalues from parallel analysis is 1.6476 and 1.4670 for component 1 and component 2 respectively. Consequently, the underlying assumption of parallel analysis is that; if the eigenvalue obtained through the PCA results is larger than the randomly generated eigenvalue from parallel analysis, the factor is to be retained and if the PCA eigenvalue is less, the factor must be rejected.

Therefore, it is obvious from the results in Table 6.11 and Table 6.12 that, only the first component could be retained since its eigenvalue is greater than parallel analysis randomly generated eigenvalue (5.801 > 1.6476). While the second component is rejected since, its eigenvalue is less than parallel analysis random eigenvalue (1.365 < 1.4670). Further rotation was conducted on the variables using fixed factor extraction loading; in this case, 1 was specified as the number of the component to be extracted to ascertain the percentage variance that would be explained by one component. The results of 1 component extraction showed an eigenvalue of 5.808 and total variance explained by the component was 44.68%, which is less than the total variance explained by two components.

Summarily, the result obtained through parallel analysis is not in agreement with the results of PCA and the Catell’s scree test. However, Pallant (2012) and Tabachnick & Fidell (2012) have noted that the results of Catell’s scree test and Parallel analysis are necessary to confirm the results of Kaiser’s criterion analysis to ensure that appropriate decisions are taken on the number of components to be retained. Based on the foregoing, this study accepted and retained two components for further investigation, this decision is from the scree plot (Figure 6.3) and the Kaiser’s criterion analysis.

Table 6. 12 Output of parallel analysis

Monte Carlo PCA for Parallel Analysis
Number of variables: 13
Number of subjects: 105
Number of replications: 100

Eigenvalue #	Random Eigenvalue	Standard Dev
1	1.6476	.1110
2	1.4670	.0622
3	1.3382	.0418
4	1.2433	.0441
5	1.1411	.0438
6	1.0468	.0397
7	0.9703	.0342
8	0.8867	.0400
9	0.8153	.0361
10	0.7293	.0337
11	0.6557	.0355
12	0.5739	.0392
13	0.4849	.0368

Monte Carlo PCA for Parallel Analysis ©2000 by Marley W. Watkins.

6.4.2.2.1 Presenting the Summary of PCA Results

This study identified 13 variables that have positive and negative effects on achieving users' satisfaction by the construction industry in affordable housing. The 13 variables (Housing Satisfaction Factor: HSF) were subjected to principal component analysis using SPSS. Subsequent to performing PCA, the suitability of data for factor analysis was assessed and the results were reported in section 6.4.2.1. The Kaiser-Meyer-Olkin value was 0.868, exceeding the recommended value of 0.6, and Bartlett's Test of Sphericity was significant at $p = 0.000$ ($p< 0.5$) supporting the factorability of the correlation matrix.

The PCA revealed two components with eigenvalues exceeding 1, explaining 44.62% and 10.5% of the variance respectively, this is exhaustively reported in section 6.4.2.2 of this thesis. A careful inspection of the scree plot shows a clear break after the second component, while the parallel analysis revealed only one component as having its eigenvalue larger than the randomly generated data matrix of the same size from MonteCarloPA. This study thus decided to retain two components for further investigation.

This study adopts the use of Oblimin rotation to aid the interpretation of the two components retained, and for loading the variables. The results in Table 6.13 revealed both components showing a number of strong loadings, all variables loaded substantially above 0.6 on Pattern Matrix and above 0.3 on Structure Matrix on the two components. The communalities values show that the variables fit well into the component with all the HSF variables having above 0.4, though the communalities value of 0.42 exhibited by HSF6 (Household size) shows the variable contributed the least to the component. There was positive correlation between the two components (*r = 0.42*). Considering the loading pattern of HSF variables, the variables that converge on component 1 represent building materials that enhance reduction in operating cost of building while component 2 could be regarded as socio-economic attributes of the housing user.

Table 6. 13 Pattern and Structure Matrix for PCA with Oblimin Rotation of HSF Variables

Coding	Variables	Pattern coefficients		Structure coefficient		Communalities
		Component 1	Component 2	Component 1	Component 2	
HSF8	Energy savings electrical appliance	**.779**		.765		**.586**
HSF11	Water savings sanitary and Plumbing appliances	**.772**		.792	.371	**.629**
HSF7	Building users access to medical facilities	**.741**		.761	.357	**.580**
HSF12	Neighbourhood socio economic status	**.734**		.776	.408	**.610**
HSF6	Household Size	**.716**		.614		**.426**
HSF9	Sustainability Building Materials not aesthetically pleasing	.574		.646	.413	.442
HSF13	Building forms	.566	.353	.713	.590	.612
HSF5	Lack of access to relevant information on availability of sustainable materials	.556		.632	.415	.427
HSF1	Budget constraints		**.829**		.742	**.586**
HSF3	Lots of time and man power in analysing and selection of construction materials		**.723**	.417	.771	**.606**
HSF2	Cost of eco-friendly Building materials		**.628**	.425	.696	**.506**
HSF4	Building aesthetics	.306	.561	.541	.689	.552
HSF10	Privacy from neighbours	.376	.539	.601	.696	.601

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 8 iterations.

6.5 PROBLEMS THAT MITIGATE USAGE OF SUSTAINABLE BUILDING MATERIALS

One of the primary efforts of this research is to enhance sustainability in construction of affordable housing. To pursue this objective, a number of concerns were identified to measure the perception of construction stakeholders on impediments towards usage of sustainable building materials for the construction of housing for the poor population.

6.5.1 Motivates for Selection of Sustainable Building Materials

The results in Table 6.14 and Table 6.15 show the descriptive statistics and frequency analysis results for the factors that motivate construction professionals to use sustainable building materials. Nine variables were put forward to the professionals to test their level of agreement of the factors towards motivating them into specifying and adopting the use of sustainability concepts for housing projects. Further to the analysis, approximately 90% of the respondents agree that the need to preserve the natural environment is the main motive for their usage of sustainable building materials. The factor is thereby ranked first with a mean score value of 4.3143. The need to conduct life cycle assessment of materials ranked second with a mean score value of 4.1619. The high mean score recorded was attested to by approximately 81% of the respondents who agreed that life-cycle assessment is a strong motive for using sustainable building materials. From the results, the third ranked motive for using sustainable building materials is the general belief that sustainable materials increase building cost and construction time having a mean score value of 3.9333, supported by approximately 73% of the respondents.

Other motives, according to the ranking based on respondents' perceptions are; availability of a sustainable building materials manual in RSA (ranked fourth), use of sustainable building materials is a mandatory requirement for building projects (ranked fifth) and reduction in construction cost of building, which was ranked sixth. All of these factors were supported by approximately over 58% of the respondents. Therefore, the results have shown that professionals in the construction industry in RSA are generally attuned to the use of sustainable building materials notwithstanding the attendant increase in cost of building construction.

Table 6. 14 Perceived motivating factors towards use of sustainable materials

Coding	Factors	Minimum	Maximum	Mean	Std. Deviation	Rank
MSF3	Preserve the natural environment	2.00	5.00	4.3143	.6838	1
MSF9	Architect Must Conduct Life Cycle Assessment of Materials	2.00	5.00	4.1619	.8449	2
MSF5	Belief That Environment friendly Materials Cause Increase In Construction Cost and Time	2.00	5.00	3.9333	.8578	3
MSF1	Availability of Guides for Selecting Sustainable materials	2.00	5.00	3.8286	.9349	4
MSF2	Satisfy Mandatory Requirements	2.00	5.00	3.7714	.8350	5
MSF6	Reduction in cost of construction	2.00	5.00	3.6381	.9620	6
MSF7	Clients Prefer Sustainability Concepts Despite Increase In Cost and Time	1.00	5.00	3.6286	.8907	7
MSF4	use of sustainable materials require special consideration During Building Design	1.00	5.00	3.6095	.8491	8
MSF8	Designers Implement Sustainable Despite Increase In Cost and Time	1.00	5.00	3.4190	.8635	9

Table 6. 15 Frequency of respondents on motivates for using sustainable materials

Coding	Factors	Strongly disagree	Disagree	Indifferent	Agree	Strongly agreed	Mean score	Rank
MSF3	Preserve the natural environment	0	1%	9.5%	46.7%	42.9%	4.3143	1
MSF9	Architect Must Conduct Life Cycle Assessment of Materials	0	4.8%	14.3%	41%	40%	4.1619	2
MSF5	Belief That Environment friendly Materials Cause Increase In Construction Cost and Time	0	6.7%	20%	46.7%	26.7%	3.9333	3
MSF1	Availability of Guides for Selecting Sustainable materials	0	9.5%	24.8%	39%	26.7%	3.8286	4
MSF2	Satisfy Mandatory Requirements	0	6.7%	28.6%	45.7%	19%	3.7714	5
MSF6	Reduction in cost of construction	0	14.3%	27.6%	38.1%	20%	3.6381	6
MSF7	Clients Prefer Sustainability Concepts Despite Increase In Cost and Time	1.9%	7.6%	30.5%	45.7%	14.3%	3.6286	7
MSF4	use of sustainable materials require special consideration During Building Design	1%	3.80%	45.7%	32.4%	17.1%	3.6095	8
MSF8	Designers Implement Sustainable Despite Increase In Cost and Time	1%	10.5%	45.7%	31.4%	11.4%	3.4190	9

6.5.2 Impediments to use of Sustainable Building Materials

Descriptive statistical analysis carried out on the factors obstructing total compliance to the use of sustainable building materials by construction professionals reported on Table 6.16 and Table 6.17 have revealed that; maintenance concern is the most perceived obstacle to use of sustainable materials for housing projects. This factor is overwhelmingly supported by approximately 90% of the professionals that participated in the survey. This factor is thereby ranked first having a mean score value of 4.2952. Similarly, perception of extra cost being incurred was ranked second and building standard restriction ranked third with mean score values of 4.2476 and 4.1238 respectively. Furthermore, “lack of adequate and experienced labour to execute construction works”, “difficulties in balancing environmental, social and economic issues” and “lack of information on sustainable construction materials” are ranked fourth, fifth and sixth respectively, using their mean score values.

Table 6. 16 Perceived obstacles to use of sustainable materials

Coding		Minimum	Maximum	Mean	Std. Deviation	Rank
ISF2	Maintenance concern	2.00	5.00	4.2952	.6782	1
ISF5	Perception of Extra Cost Being Incurred	2.00	5.00	4.2476	.6762	2
ISF3	Building Standard Restrictions	2.00	5.00	4.1238	.7165	3
ISF10	Lack of adequate and experienced Labour to execute Construction Works	2.00	5.00	4.1048	.7585	4
ISF4	Difficulties In Balancing Environmental, Social And Economic Issues	1.00	5.00	4.0762	.7029	5
ISF1	Lack of Information on Sustainable Construction Materials	2.00	5.00	4.0286	.7526	6
ISF9	Unwillingness to change the conventional way of specifying building materials	1.00	5.00	3.9333	.9432	7
ISF8	Low Flexibility for Alternative or Substitutes	2.00	5.00	3.9048	.7142	8
ISF6	Perception of Extra Time Being Incurred	1.00	5.00	3.8571	.8926	9
ISF7	Perception that Building will not be Aesthetically Pleasing	2.00	5.00	3.4571	.9408	10

Table 6. 17 Frequency analysis on obstacles to use of sustainable materials

Coding	Factors	Extremely not important	Not important	Indifferent	Important	Very important	Mean score	Rank
ISF2	Maintenance concern	0	1%	9.5%	48.6%	41%	4.2952	1
ISF5	Perception of Extra Cost Being Incurred	0	1.9%	7.6%	54.3%	36.2%	4.2476	2
ISF3	Building Standard Restrictions	0	2.9%	11.4%	56.2%	29.5%	4.1238	3
ISF10	Lack of adequate and experienced Labour to execute Construction Works	0	2.9%	15.20%	50.5%	31.4%	4.1048	4
ISF4	Difficulties In Balancing Environmental, Social And Economic Issues	1%	1.9%	9.5%	63.8%	23.8%	4.0762	5
ISF1	Lack of Information on Sustainable Construction Materials	0	1.9%	21%	49.5%	27.6%	4.0286	6
ISF9	Unwillingness to change the conventional way of specifying building materials	1.9%	4.80%	21.9%	41%	30.5%	3.9333	7
ISF8	Low Flexibility for Alternative or Substitutes	0	2.9%	21.90%	57.1%	18.1%	3.9048	8
ISF6	Perception of Extra Time Being Incurred	1%	4.8%	27.6%	41%	25.7%	3.8571	9
ISF7	Perception that Building will not be Aesthetically Pleasing	0	18.1%	31.4%	37.1%	13.3%	3.4571	10

6.5.2.1 Summary Discussion of the top Five Impediments to use of Sustainable Materials

From the results of the analysis discussed in section 6.5.2, the top most impediment based on the ranking was “maintenance concern”. This inference is corroborated by Joseph and Tretsiakova-McNally (2010) who found that fear of maintenance involved in use of sustainable materials still persist in the minds of construction professionals. It is a clear fact that maintenance has a considerable impact on the performance of a building and any maintenance related problem that may occur during the life of the building can be minimised using materials that require less maintenance and have lower replacement costs. However, the perception of construction professionals as regards maintenance of buildings was unconnected to the uncertainty surrounding the long term maintenance of sustainable materials, as information relating to some basic specifications on these materials is still not adequately available. Though, maintenance free buildings are increasingly sought by clients who are apprehensive to curtail running costs associated with building operations.

The second highest ranked impediment to the use of sustainable materials is “perception of extra cost being incurred”. Costs have featured prominently in previous researches on sustainability in extant literatures (notably Fapohunda, Nicholson, Ganiyu & Solanke, 2015; Meryman & Silman, 2004; Williams & Dair, 2007). Cost of construction is mostly limited by budgeted costs for the project; once the budget is defined it has great influence on subsequent design decisions, such as material selection. It is to be noted that cost differential between conventional materials and sustainable materials have not been thoroughly investigated, construction professionals still have the notion that anything other than conventional materials will be more expensive.

Restriction on Building Standard being the third perceived impediment is a reflection of the real world situation, which construction professionals have to contend with in making design decisions for housing projects. Affordable housing projects come with lots of regulations from the government as relates to total building size (gross floor area), total cost of construction per unit, minimum expected facilities in the building, amongst other regulations. However, building approval for affordable housing is largely dependent on compliance of the building plans to the laid down regulations, thereby making design decisions on use of sustainable materials difficult for construction professionals when planning affordable housing projects.

Lack of adequate experienced skilled labour is one of the biggest obstacles to specifying sustainable materials for construction of affordable buildings. It presents a big challenge for construction professionals to specify the use of sustainable materials knowing fully well that there is less competent labour available to execute the project and to undertake maintenance during the operational life of the building. Lack of access to adequate information on sustainable materials also contribute to lack of labour, as most professionals always prefer to opt for safe solutions in situations where information on sustainable products are not readily available.

The fifth ranked impediment is the difficulties in balancing environmental, social and economic issues. The perception of respondents on this factor could be attributed to lack of assessment tools that are globally acceptable to all stakeholders in the construction industry for evaluating building sustainability. However, balancing these three parameters in a construction project will produce a development that is equitable, bearable and economically viable, thereby satisfying the ultimate goal of sustainability.

6.6 IDENTIFYING HOUSING FINANCING CONCEPT THAT ENHANCES SUSTAINABLE HOUSING CONSTRUCTION.

One of the fundamental objectives of this research is to create ways through which sustainable affordable housing could be constructed for the poor population. To achieve the construction of housing that is equitable, bearable and economically viable, the need for evaluation of housing financing concepts is imperative, to ensure the use of most economical means to both the housing developer and user of the building. Housing finance has great influence on successful delivery of a project and it is a vital component of a well–functioning housing system. Therefore, identifying the most appropriate housing financing system is crucial to the construction of sustainable housing.

6.6.1 Down Payment Grant as Housing Finance system

Down payment grant is a housing financing system where an interest free loan is granted to a prospective homebuyer at the point of sale of the house. The results of analysis on the factors considered for the use of down payment grant as a financing system, reported in Table 6.18, showed that approximately 55% of the construction professionals surveyed strongly agreed that the system, when used to finance a housing project, encourages user participation right from the planning stage through to completion stage. More so, 55% and 57% agreed that the concept is most preferred due to the fact that it encourages home buyer contribution to help mortgage repayment, and its responsive nature reduces payment default by the home buyer. Approximately 50% agreed that down payment grant enhances delivery of sustainable affordable housing.

Using the mean score value of the variables as shown in Table 6.18, encouragement of user participation was ranked first (mean score value = 3.6667), encouragement of homebuyer contribution was ranked second (mean value = 3.6667), responsiveness to reduction in payment default was ranked third and enhancement of delivery of sustainable affordable housing ranked fourth.

Table 6. 18 Descriptive statistics on Down-payment grant to finance housing project

Coding	Variables	Frequency					Mean	Std. Deviation	Rank
		never	rarely	sometimes	very often	always			
HFDPG1	Strengthens commitment to deliver high quality in constructed facility	1.9%	10.5%	41.9%	31.4%	14.3%	3.4571	.9306	5
HFDPG2	Encourages user participation	1.9%	5.7%	37.1%	34.3%	21%	3.6667	.9371	1
HFDPG3	Responsive to reduction in payment default by homeowner	0	6.7%	36.2%	43.8%	13.3%	3.6381	.7981	3
HFDPG4	It encourage homebuyer contribution to help Mortgage Payments	1%	5.7%	38.1%	36.2%	19%	3.6667	.8843	2
HFDPG5	Help to achieve Government Goal of providing free housing	2.9%	29.5%	48.6%	10.5%	8.6%	2.9238	.9271	6
HFDPG6	Enhances delivery of affordable sustainable housing	1%	9.5%	39%	37.1%	13.3%	3.5238	.8781	4

6.6.2 Mortgage Payment Subsidies as Housing Finance System

Mortgage payment subsidies is a housing financing system which is a tax free mortgage revenue bond sold to investors in order to finance housing development below market interest rate mortgages. The results in Table 6.19 showed that construction stakeholders in housing development strongly prefer using mortgage payment subsidies because the system strengthens commitment to deliver high quality housing. Thus, the factor having a mean value of 3.7429 is ranked first and enhancement of delivery of affordable housing was ranked second with mean value of 3.6857. Encouragement of user participation and reduction in payment default by the home owner were ranked third and fourth respectively.

Table 6. 19 Analysis on “Mortgage payment subsidies” to finance housing project

Coding	Variables	Frequency never	rarely	sometimes	very often	always	Mean	Std. Deviation	Rank
HFMPS4	Strengthens commitment to deliver high quality in constructed facility	0	6.7%	33.3%	37.1%	22.9%	3.743	.8663	1
HFMPS1	Enhance delivery of affordable sustainable housing	1%	7.6%	29.5%	41.9%	20.00%	3.686	.8004	2
HFMPS2	Encourage user participation	0	7.6%	37.1%	39%	16.2%	3.667	.8951	3
HFMPS3	Respond to reduction in payment default by homeowner	0	8.6%	47.6%	29.5%	14.3%	3.533	.9206	4
HFMPS6	Access mortgage with little payment support	1.9%	8.6%	37.1%	41%	11.4%	3.486	.8334	5
HFMPS5	Help to achieve government providing free housing	2.9%	35.2%	38.1%	14.3%	9.5%	2.952	.9745	6

6.6.3 Mortgage Interest Deduction as Housing Finance system

The results of analysis in Table 6.20 showed that approximately 66% of the respondents strongly prefer mortgage interest deduction for housing financing, due to commitment to delivering high quality in housing. Sixty one per cent (61%) of the respondents perceived enhanced delivery of affordable sustainable housing as motive for using mortgage interest deduction and encouragement of user participation was strongly supported by approximately 57%. Furthermore, reduction in payment default by homeowner was motivated for by approximately 51.4% of the construction professionals in housing development. However, the mean score value of the descriptive analysis was used to rank the factors and the variables were ranked as follows: commitment to delivering high quality housing (ranked first with mean value = 3.7429), enhanced delivery of affordable sustainable housing (second with mean value = 3.6857), encouragement of user participation (third with mean value = 3.6667) and reduction in payment default by homeowner as the fourth ranked variable.

Table 6. 20 Descriptive statistics on “Mortgage interest deduction” to finance housing project

Coding	Variables	Frequency					Mean	Std. Deviation	Rank
		never	rarely	sometimes	very often	always			
HFMID4	Strengthens commitment to deliver high quality in constructed facility	0	9.5%	24.8%	47.6%	18.1%	3.7429	.8663	1
HFMID1	Enhance delivery of affordable sustainable housing	0	6.7%	32.4%	46.7%	14.3%	3.6857	.8004	2
HFMID2	Encourage user participation	0%	9.5%	33.3%	38.1%	19%	3.6667	.8951	3
HFMID3	Respond to reduction in payment default by Homeowner	2.9%	6.7%	39%	37.1%	14.3%	3.5333	.9206	4
HFMID6	Access mortgage with little payment support	1.9%	6.7%	41.9%	40%	9.5%	3.4857	.8334	5
HFMID5	Help to achieve government in providing free housing	2.9%	31.4%	42.9%	13.3%	9.5%	2.9524	.9745	6

6.6.4 Using “Subsidies” as Housing Finance system

“Subsidies” is a housing financing option aimed to lower both the initial purchase price and monthly repayment, and providing financial assistance to home owners. The results of analysis on the factors considered for the use of subsidies as a financing system reported in Table 6.21 showed that approximately 79% of the construction professionals surveyed strongly agreed that the subsidies system, when used to finance housing projects, help the government to achieve their goal of providing free housing to the poor population. Fifty seven per cent (57%) agreed that the concept encourages resale of the house below market price and approximately 40% agreed that the subsidies system enhances delivery of sustainable affordable housing.

Using the mean score value of the variables as shown in Table 6.21, achievement of government’s goal of providing free housing was ranked first (mean score value = 4.2762), encouragement of resale of home below market price was ranked second (mean value = 3.6095), and enhancement of delivery of sustainable affordable housing ranked third with mean value of 3.4190.

Table 6. 21 Descriptive analysis on subsidies system of housing financing

Coding	Variables	Frequency					Mean	Std. Deviation	Rank
		never	rarely	sometimes	very often	always			
HFS5	Help achieve government goal of providing free Housing	1%	9.5%	10.5%	19%	60%	4.2762	1.0515	1
HFS6	Encourages resell of the Home by buyer below market price	1%	5.7%	36.2%	45.7%	11.4%	3.6095	.8026	2
HFS1	Enhances delivery of affordable sustainable housing	0	10.5%	49.5%	27.6%	12.4%	3.4190	.8410	3
HFS2	Encourage users participation	0	22.9%	41%	24.8%	11.4%	3.2476	.9383	4
HFS4	Strengthen commitment to deliver high quality in Constructed facility	0	19%	48.6%	22.9%	9.5%	3.2286	.8689	5
HFS3	Responsive to payment default by Homeowner	0	26.7%	44.8%	20%	8.6%	3.1048	.8979	6

6.6.5 Credit Enhancement as Housing Finance System

The results of analysis in Table 6.22 showed that approximately 54% of the respondents strongly prefer credit enhancement to finance housing, since it enhances sustainable housing delivery. Fifty five per cent (55%) of the respondents preferred access to mortgage with little support, and encouragement of user participation was strongly supported by approximately 53%. Furthermore, commitment to delivering high quality housing was motivated for by approximately 53% of the construction professionals in housing development. The mean score value of the descriptive analysis was used to ranked the factors and the variables were ranked as follows: enhancement of sustainable housing delivery ranked first, access to mortgage with little support ranked second, encouragement of user participation was ranked third and commitment to deliver high quality housing was ranked fourth.

Table 6. 22 Descriptive analysis on Credit Enhancement system of housing financing

Coding	Variables	Frequency					Mean	Std. Deviation	Rank
		never	rarely	sometimes	very often	always			
HFCE1	Enhances delivery of affordable Sustainable Housing	1%	7.6%	37.1%	32.4%	21.9%	3.6667	.9371	1
HFCE6	Access to mortgage with little support	0	5.7%	390%	40%	15.2%	3.6476	.8084	2
HFCE2	Encourages user participation in design	1%	9.5%	36.2%	33.3%	20%	3.6190	.9444	3
HFCE4	Strengthens commitment to deliver high quality in Constructed House	0	12.4%	34.3%	34.3%	19%	3.6000	.9364	4
HFCE3	Responsive to reduction in payment default by Owner	0	10.5%	39%	34.3%	16.2%	3.5619	.8871	5
HFCE5	Help to achieve government free Housing policy	2.9%	21.9%	54.3%	11.4%	9.5%	3.0286	.9141	6

6.6.6 Housing Financing System that Enhance Sustainability Adoption in Affordable Housing Construction

This study has identified five housing financing concepts and seven variables upon which the choices of the concepts are determined by the housing developers. Further to the descriptive statistical analysis conducted on each of the housing financing concepts reported in sections 6.6.1 to 6.6.5, the cross tabulation of the variables and the financing concept was carried out using the mean score value of each variable as they fare in the descriptive analysis. As indicated on the results of analysis in Table 6.23, the average mean score values of the variables across all financing concepts were calculated and the median of the mean value was equally determined.

The average mean score calculated was then used to rank the variables in order of their contribution the choice of the concepts under investigation. Enhanced delivery of affordable housing ranked first (average mean value = 3.5962), encouragement of user participation was ranked second (avg. mean value = 3.5733), commitment to delivering high quality ranked third (avg. mean value = 3.5543), reduction in payment default by home owners was ranked fourth (avg. mean value = 3.4743) and realisation of government's goal of achieving free housing policy ranked fifth (avg. mean value = 3.2267).

Moreover, to ascertain housing financing concepts that could best be used to finance affordable housing projects to ensure adherence to sustainability, the median of the variables was computed, the median value was then used as the threshold value upon which the significant variables under each of the concepts were determined. The results showed that Down payment grant, Mortgage payment subsidies, Mortgage interest deduction and Credit enhancement have strong statistical correlation with the first five most ranked variables. These results demonstrate that combining these housing financing concepts is important for the realisation of sustainable affordable housing. This inference is thus corroborated by Warnock and Warnock (2008:250) who opine that in emerging economy countries, there is a need for development of capital markets that will foster the provision of housing finance on the supply side and could further increase the supply of capital. Warnock and Warnock (2008:14) further express that concerted efforts are required by government to strengthen legal rights and deepening credit information systems, to enable the poor to have access to housing finance. Though, of the 12 million households in South Africa, roughly 3 million do not qualify for any sort of mortgage product (Rust, 2008:9; Melzer, 2006), hence the need to adopt housing finance programmes to create social capital, engage in capacity building and encourage low-income households to save (Datta & Jones, 2001:353). Therefore, merging two or more concepts will provide a new model to avoid the low-income population from drifting into relative poverty, and to allow financiers of housing to actively pursue an ethical return on their investment.

Table 6. 23 Housing financing concept to achieve sustainable affordable housing construction

Coding	Variables	Housing Financing options Mean scores					Mean Average	Median	Rank
		Down Payment Grant	Mortgage Payment Subsidies	Mortgage Interest Deduction	Subsidies	Credit Enhancement			
HFSV2	Enhances delivery of affordable sustainable housing	3.5238	3.6857**	3.6857**	3.4190	3.6667**	3.5962	3.6667	1
HFSV3	Encourages user participation	3.6667**	3.6667**	3.6667**	3.2476	3.6190	3.5733	3.6667	2
HFSV1	Strengthens commitment to deliver high quality in constructed facility	3.4571	3.7429**	3.7429**	3.2286	3.6000**	3.5543	3.6000	3
HFSV4	Responsive to reduction in payment default by homeowner	3.6381**	3.5333**	3.5333**	3.1048	3.5619**	3.4743	3.5333	4
HFSV5	Help to achieve Government Goal of providing free housing	2.9238	2.9524**	2.9524**	4.2762**	3.0286**	3.2267	2.9524	5
HFSV6	It encourage homebuyer contribution to help Mortgage Payments	3.6667**	3.4857**	3.4857**	0	3.6476**	2.8571	3.4857	6
HFSV7	Encourages resell of the Home by buyer below market price	0	0	0	3.6955	0	0.7391	0	7

**significant at mean value ≥ median value

6.7 FACTORS INFLUENCING COST OF SUSTAINABLE HOUSING CONSTRUCTION

Affordable housing construction is a social and capital investment that takes centre stage in providing healthy living for the people, and realising its construction in a cost efficient way is dependent on some factors which has either positive or negative influences on the construction cost. These factors were categorised under five sub-headings, namely: environmental, stakeholders related, construction/project related, cost estimating and financing factors.

The results of descriptive statistical analysis in Table 6.24 on environmental factors that influence cost of housing construction showed that use of modern building materials has mean score value of 4.2952, availability of skilled labour within the vicinity of project has mean score (3.7333), and project location has mean score of 3.6762. Thus, the factors were ranked first, second and third, respectively. The descriptive analysis of the second set of data, categorised as "stakeholders' related factors", showed that design consideration has a mean score value of 4.2095, material standard has a mean score value of 4.1714 and lack of coordination has a mean score value of 3.9524. The construction related factors exhibited mean score values as follows; change in design (4.1238), contract management (3.9714) and contract period (3.9333). The cost estimating factors showed the following: cost of materials (mean score = 4.4286), cost of labour (4.1905) and lending rate (mean score = 3.8190). The factor categorised as financing factors showed that: mode of financing bonds and payment has a mean score value of 4.0857, inflationary pressures mean score was 4.0762 and exchange rate has a mean score of 3.7810.

However, to identify the underlying variables that influence cost of housing construction amidst all these variables, a further analysis was conducted using PCA. The results of PCA analysis is presented in the subsequent section 6.7.1.

Table 6. 24 Descriptive analysis on factors influencing cost of construction

Coding	Variables	Minimum	Maximum	Mean	Std. Deviation	Rank
	Environmental factors					
FCCE5	Use of modern building materials	2.00	5.00	4.2952	.7585	1
FCCE7	Availability of skilled labour within the project vicinity	1.00	5.00	3.7333	.8117	2
FCCE3	Project location	1.00	5.00	3.6762	.8144	3
FCCE4	Use of natural building materials	1.00	5.00	3.5905	.8514	4
FCCE2	Energy usage during construction	1.00	5.00	3.5143	.8333	5
FCCE1	Effects of Weather	2.00	5.00	3.3238	.8604	6
FCCE6	Tax incentive on implementation of sustainable construction practice	1.00	5.00	2.7048	1.1678	7
	Stakeholders related factor					
FCS3	Design consideration	2.00	5.00	4.2095	.6308	1
FCS4	Material standard	1.00	5.00	4.1714	.6996	2
FCS2	Lack of coordination	1.00	5.00	3.9524	.7516	3
FCS5	Financial control on site	2.00	5.00	3.9333	.7877	4
FCS1	Incorrect planning	1.00	5.00	3.9143	.7735	5
	Construction related factors					
CRF3	Change in Design	1.00	5.00	4.1238	.7297	1
CRF1	Contract management	1.00	5.00	3.9714	.7777	2
CRF4	Contract period	1.00	5.00	3.9333	.8117	3
CRF2	Contract procedure	1.00	5.00	3.8857	.8123	4
	Cost estimating factors					
CEF1	Cost of materials	3.00	5.00	4.4286	.5693	1
CEF2	Cost of Labour	2.00	5.00	4.1905	.6664	2
CEF5	Lending Rate	2.00	5.00	3.8190	.7939	3
CEF4	Allowance for waste	1.00	5.00	3.7905	.7683	4
CEF3	Cost of Machinery	2.00	5.00	3.5905	.9061	5
	Financing Factors					
CCFF1	Mode of financing bonds and payments	2.00	5.00	4.0857	.7221	1
CCFF2	Inflationary pressure	2.00	5.00	4.0762	.7428	2
CCFF3	Exchange rate	2.00	5.00	3.7810	.7964	3

6.7.1 Identifying the Underlying Factors Influencing Cost of Sustainable Housing Construction

In order to ascertain the underlying factors influencing cost of sustainable housing construction, Principal Component Analysis (PCA) was performed, to reduce and further classify the variables for model development. It is to be noted that benefits and justification for the use of PCA, when confronted with the task of identifying underlying variable influencing a specific objective, has been exhaustively discussed in section 6.4.2 of this thesis.

6.7.1.1 K.M.O. Adequacy and Bartlett's Sphericity Test

The first step in PCA analysis is to test the appropriateness of a study data for PCA analysis (Pallant, 2012:192), hence the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's test of Sphericity of the identified variable influencing cost of sustainable housing construction were determined. Table 6.25 shows the results of KMO and Bartlett's test of Sphericity. These tests provide the basis for measuring the minimum standard that the data must satisfy before being considered adequate for PCA. The KMO index ranges from 0 to 1, with 0.6 suggested as the minimum value for a good factor analysis (Pallant, 2012; Tabachnick, & Fidell, 2012). The Bartlett's test of Sphericity indicates the strength of the relationship among variables and it should be significant at $p<0.05$ for the PCA to be considered appropriate (Pallant, 2012; Tabachnick, & Fidell, 2012). The results in Table 6.25 display KMO value of 0.802 which is greater than 0.6 and less than 1, while the Bartlett's Sphericity value p = 0.000 (i.e. p<.5). This therefore showed that the data is adequate and suitable for PCA.

Table 6. 25 KMO and Bartlett's Test on variables influencing construction cost

Test		Value	Remark
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.802	Significant and adequate for PCA
Bartlett's Test of Sphericity	Approx. Chi-Square	1330.761	Significant and adequate for PCA
	df	276	
	Sig. (p<.5)	.000	

6.7.1.2 Principal Components Factors Influencing Construction Cost of Housing

According to Pallant (2012), the next step after establishing the appropriateness and suitability of the research data is component (factor) extraction. This is a process to ascertain the number of components to retain, based on their contribution to the construct since not all factors are to be kept (Tabachnick & Fidell, 2012). The most commonly used method of factor extraction in PCA include: Kaiser's criterion; using eigenvalue greater than 1 rule; Catell's scree test; retaining all factors above the elbow in the structure and Horn's parallel analysis; comparing the eigenvalue with those randomly generated from data set of the same size (Pallant, 2012:184).

To extract the components influencing construction cost of housing, "Kaiser's criterion using eigenvalues" was adopted and varimax rotation was used to extract the variables that load on each identifiable component. However, the significant factors according to Kaiser's criterion are those factors with eigenvalues above 1. In Table 6.26, six components that have their initial eigenvalues greater than 1 were extracted from the construction cost variables influencing housing construction. The eigenvalues of the six extracted components are; 6.679, 3.184, 2.430, 1.820, 1.559 and 1.054; the result shows that the first component is capable of explaining 27.83% of the variance, the second component explained 13.27% of the variance, third component explained 10.12% of the variance and the fourth, fifth and sixth components explained 7.58%, 6.49% and 4.39% of the variance respectively. However, the six components combined to explain 69.69% of the total variance, which shows that these components a have very significant influence on the cost of housing construction.

Table 6. 26 Total variance explained by construction cost influencing PCA

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.679	27.829	27.829	6.679	27.829	27.829	4.055
2	3.184	13.269	41.097	3.184	13.269	41.097	3.271
3	2.430	10.123	51.221	2.430	10.123	51.221	4.135
4	1.820	7.582	58.803	1.820	7.582	58.803	3.947
5	1.559	6.494	65.297	1.559	6.494	65.297	1.696
6	1.054	4.390	69.687	1.054	4.390	69.687	3.376
7	.870	3.626	73.313				
8	.755	3.147	76.460				
9	.702	2.926	79.386				
10	.665	2.770	82.156				
11	.509	2.119	84.275				
12	.496	2.067	86.342				
13	.447	1.864	88.206				
14	.396	1.651	89.857				
15	.365	1.523	91.380				
16	.348	1.452	92.832				
17	.316	1.318	94.150				
18	.289	1.205	95.355				
19	.261	1.086	96.440				
20	.213	.887	97.328				
21	.201	.838	98.166				
22	.170	.709	98.875				
23	.149	.621	99.496				
24	.121	.504	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

To further confirm the number of components to retain, Catell’s scree test was performed on the variable and the results in Figure 6.4 (scree plot) shows that six components are retained. These components are the point, which is above the elbow on the scree plot shown in figure 6.4. These components, however, contribute the most to the variance in the data set, and this agrees with the results displayed on Table 6.26.

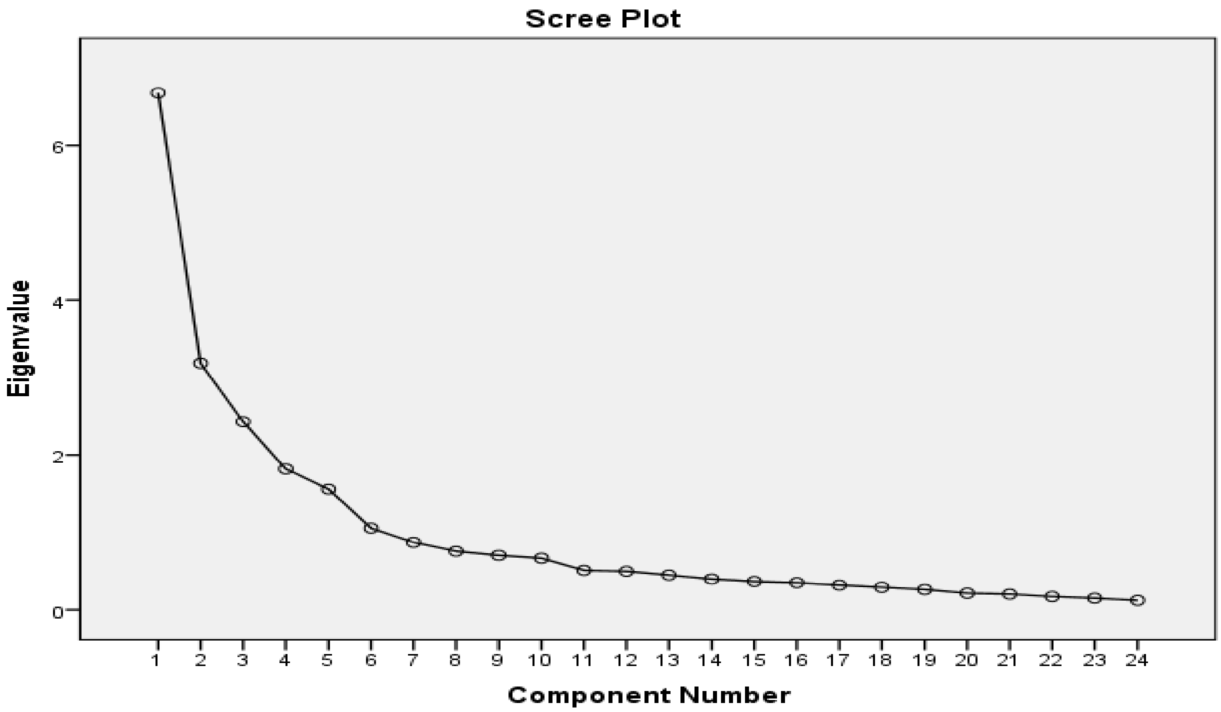

Figure 6. 4: Catell's scree plot on variables influencing cost of housing construction

Pallant (2012) and Tabachnick and Fidell, (2012) suggested further confirmation before a conclusion could be reached on the number of components to be retained when PCA is used. The authors suggested that “Parallel analysis” be used to ascertain the components before taking a decision on the number of components to retain. Parallel analysis involves comparing the size of the eigenvalues with those obtained through a randomly generated data set using the ‘MonteCarloPA application package’. It is worthy to note that parallel analysis has been adjudged the most appropriate technique to identify the correct number of components to retain (Pallant, 2012; Tabachnick & Fidell, 2012). Although, the authors cautioned that the results of parallel analysis be interpreted amidst Kaiser’s criterion and Catell’s scree test to determine the number of components to be retained. The criterion eigenvalue of the six components are; 6.679, 3.184, 2.430, 1.820, 1.559 and 1.054 (see Table 6.26), while the corresponding random eigenvalues from parallel analysis for the first six components are; 1.8106, 1.6720, 1.5692, 1.4771, 1.4021 and 1.3343 respectively.

The underlying assumption of parallel analysis is that if the eigenvalue obtained through the PCA results is larger than the randomly generated criterion eigenvalue from parallel analysis, the factor is to be retained and if the PCA eigenvalue is less, the factor must be rejected. Therefore, it is obvious from the results in Table 6.26, Table 6.27 and Table 6.28 that only five components could be retained, since their criterion eigenvalues are greater than parallel analysis random eigenvalues. The sixth component is rejected since its criterion eigenvalue is less than parallel analysis random eigenvalue (1.054 < 1.3343).

Summarily, the result obtained through parallel analysis is not in agreement with the results of PCA and the Catell's scree test. However, Pallant (2012) and Tabachnick & Fidell (2012) have noted that the results of Catell's scree test and Parallel analysis are necessary to confirm the results of Kaiser's criterion analysis, to ensure that appropriate decisions are taken on the number of components to be retained. Based on the aforementioned, this study accepted and retained five components for further investigation, a decision based on the results obtained from the Monte Carlo parallel analysis presented in Table 6.28.

Table 6. 27 Output of parallel analysis

Monte Carlo PCA for Parallel Analysis
Number of variables: 24
Number of subjects: 105
Number of replications: 100

Eigenvalue #	Random Eigenvalue	Standard Dev
1	1.8106	.0743
2	1.672	.0506
3	1.5692	.0512
4	1.4771	.0426
5	1.4021	.0419
6	1.3343	.0367
7	1.2668	.0327
8	1.201	.0296
9	1.1386	.0288
10	1.0853	.0263
11	1.0346	.0269
12	0.9809	.0264
13	0.9309	.0284
14	0.8785	.0256
15	0.8274	.0241
16	0.7809	.0242
17	0.739	.0255
18	0.6886	.0225
19	0.6482	.0249
20	0.6037	.0279
21	0.5574	.0264
22	0.5083	.0266
23	0.4598	.0266
24	0.4046	0.0321

Monte Carlo PCA for Parallel Analysis ©2000 by Marley W. Watkins.

Table 6. 28 Comparison of PCA eigenvalue with parallel analysis eigenvalue

Component number	Actual eigenvalue from PCA	Random eigenvalue from parallel analysis	Decision
1	6.679	1.8106	accept
2	3.184	1.672	accept
3	2.430	1.5692	accept
4	1.820	1.4771	accept
5	1.559	1.4021	accept
6	1.054	1.3343	reject

6.7.1.2.1 Presenting the Summary of PCA on Cost of Construction

This study identified 24 variables that have positive and negative influences on the cost of affordable housing construction. The variables, after initial descriptive statistical analysis, were subjected to principal components analysis using SPSS. Before performing PCA, the suitability of data for factor analysis was assessed and the results were reported in section 6.7.1.1. The Kaiser-Meyer-Olkin value was 0.802 exceeding the recommended value of 0.6 and Bartlett's Test of Sphericity was significant at $p = 0.000$ ($p < .5$) supporting the factorability of the correlation matrix.

The PCA revealed six components with eigenvalues exceeding 1, explaining 69.69% total variance (this is reported in section 6.7.1.2 of this thesis). A careful inspection of the scree plot showed a clear break after the sixth component, while the parallel analysis revealed five out of the six components to have their eigenvalue larger than the randomly generated data matrix of the same size from MonteCarloPA. This study thus decided to retain the five components for further investigation.

This study adopts use of Oblimin rotation, to aid the interpretation of the five components retained and for loading the variables. The results in Table 6.29 and Table 6.30 revealed factor loadings to the components. The higher the absolute value of the loading, the more the contribution of the variable to the component (factor). When performing the PCA analysis, small factor loadings with an absolute value less than 0.3 were suppressed to simplify the component extraction process. Moreover, the variables loaded substantially above 0.3 on both the Pattern Matrix and Structure Matrix on the five components. The communalities values show that the variable fit well into the component with all the variables having above 0.4. Though the communalities value of 0.42 exhibited by CEF1 (cost of materials) shows the variable contributed the least to the component. There was positive correlation between the five components as evident from the total variance (65.3%) explained by the components. Considering the loading pattern of cost of construction variables, the variables that converge on component 1 represent “economy of construction”, component 2 was named “contract management”, component three is “project team expertise”, component four is “socio-environmental influence” and component five is “technology and innovation”.

Table 6. 29 extraction of factors influencing housing construction cost

Coding	Variables	Pattern Matrix Coefficient & Component					Structure Matrix Coefficient & Component					Communalities
		1	2	3	4	5	1	2	3	4	5	
CCFF2	Inflationary pressure	.873					.861			.305		.757
CCFF1	Mode of financing bonds and payments	.841					.835					.745
CCFF3	Exchange rate	.769					.709					.585
CEF5	Lending Rate	.646					.713			.444		.578
CEF2	Cost of Labour	.542					.671	.322	.455	.368		.662
CEF4	Allowance for waste	.541					.601		.399			.519
CEF1	Cost of materials	.532					.583					.420
CEF3	Cost of Machinery	.386			.382	.379	.582		.349	.539	.376	.657
CRF1	Contract management		.865					.863				.756
CRF2	Contract procedure		.829					.834				.702
CRF3	Change in Design		.803					.808				.666
CRF4	Contract period		.734					.749		.331		.661
FCS3	Design consideration			.852					.816			.763
FCS2	Lack of coordination			.792			.300		.838			.784
FCS1	Incorrect planning			.763					.796			.702
FCS5	Financial control on site			.687			.406		.753			.712
FCS4	Material standard			.683		.538			.679		.535	.764
FCCE6	Tax incentive on implementation of sustainable construction practice				.759		.371			.778		.691
FCCE4	Use of natural building materials				.726					.736		.590
FCCE3	Project location				.704		.374			.736		.590
FCCE1	Effects of Weather			.325	.677				.415	.712		.613
FCCE7	Availability of skilled labour within the project vicinity				.609	.401				.603	.414	.593
FCCE2	Energy usage during construction				.567					.585		.504
FCCE5	Use of modern building materials	.317				.647	.323			.312	.666	.654

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 12 iterations.

Table 6. 30 loading of construction cost determinant variables to different component

Coding	Variables	Pattern Matrix Coefficient & Component					Structure Matrix Coefficient & Component					Communalities
		1	2	3	4	5	1	2	3	4	5	
CCFF2	Inflationary pressure	.873					.861					.757
CCFF1	Mode of financing bonds and payments	.841					.835					.745
CCFF3	Exchange rate	.769					.709					.585
CEF5	Lending Rate	.646					.713					.578
CEF2	Cost of Labour	.542					.671					.662
CEF4	Allowance for waste	.541					.601					.519
CEF1	Cost of materials	.532					.583					.420
CEF3	Cost of Machinery	.386					.582					.657
CRF1	Contract management		.865					.863				.756
CRF2	Contract procedure		.829					.834				.702
CRF3	Change in Design		.803					.808				.666
CRF4	Contract period		.734					.749				.661
FCS3	Design consideration			.852					.816			.763
FCS2	Lack of coordination			.792					.838			.784
FCS1	Incorrect planning			.763					.796			.702
FCS5	Financial control on site			.687					.753			.712
FCS4	Material standard			.683					.679			.764
FCCE6	Tax incentive on implementation of sustainable construction practice				.759					.778		.691
FCCE4	Use of natural building materials				.726					.736		.590
FCCE3	Project location				.704					.736		.590
FCCE1	Effects of Weather				.677					.712		.613
FCCE7	Availability of skilled labour within the project vicinity				.609					.603		.593
FCCE2	Energy usage during construction				.567					.585		.504
FCCE5	Use of modern building materials					.647					.666	.654

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 12 iterations.

6.8 IDENTIFYING CONSTRUCTION METHOD THAT ENHANCE SUSTAINABILITY IN HOUSING CONSTRUCTION

One of the objectives which this study intends to achieve is to ascertain the appropriate construction methods upon which construction of sustainable housing could be achieved. It is against this background that four construction methods were identified after an extensive literature search. The identified construction methods from literatures were presented to construction professionals during the preliminary interview conducted to establish the existence of the study problem with the RSA affordable housing construction industry. The analysis of the pilot interview revealed the factor that guides construction professionals in choosing a construction method for housing projects, as well as balancing the economic, environmental and socio-cultural attributes of the project.

6.8.1 Project Objective to Achieve Construction of Affordable Housing

Research participants were asked to rate the importance attached to the identified project objective on a scale of 1 – 5. Their responses were then collated and coded for statistical analysis. The data was analysed using descriptive statistics on SPSS and the result is displayed in table 6.31. The results of analysis in Table 6.31 showed that all the six project objectives presented to the study respondents were accorded some reasonable level of importance, due the fact that all of the project objectives received zero percent (0%) rating as extremely not important, while only 1.9% of the respondents adjudged "satisfy building regulation requirements" as not important.

The general overview of the results showed that all variables are relevant to measuring project success. Minimise cost-in-use has the highest mean score value (4.5905), followed by minimise capital cost of construction with a mean score value of 4.4095, satisfy client requirement has a mean score value of 4.4000 and minimise building impact on the environment has a mean score value of 4.2571. Thus, the variables were ranked first, second, third and fourth respectively. It can be inferred from the results that for a construction method to enhance sustainability in affordable housing, such a method must promote these project objectives. This result is in agreement with the findings of Ahadzie, *et al.,* (2008), which classified the determinants of success in Mass Housing Building Projects (MHBPs) into four main clusters, namely, environmental impact, customer's satisfaction, quality, and cost and time. Hence the analysis on the factors guiding construction professionals when choosing a method to execute housing construction.

Table 6. 31 pertinent project objectives that aid sustainable affordable housing construction

Coding	Variables	Frequency: Extremely not important	Not important	Indifferent	Important	Very important	Mean score	Std. Deviation	Rank
POB5	Minimise building cost in use	0%	0%	1.9%	37.1%	61%	4.5905	.5316	1
POB3	Minimise capital cost of construction	0%	0%	5.7%	47.6%	46.7%	4.4095	.5996	2
POB2	Satisfy clients specification	0%	0%	1%	58.1%	41%	4.4000	.5114	3
POB6	Minimise building impact on the environment	0%	0%	11.4%	51.4%	37.1%	4.2571	.6508	4
POB4	Meet project time and duration	0%	0%	8.6%	61.9%	29.5%	4.2095	.5833	5
POB1	Satisfy building regulation requirements	0%	1.9%	14.3%	60%	23.8%	4.0571	.6769	6

6.8.2 Extent to which ‘’Traditional construction’’ Supports Sustainability Enhancement in Building Construction

Table 6.32 and Table 6.33 present the results of the descriptive analysis on the level to which the ‘’traditional construction concept’’ influences sustainable housing construction. To put the results in perspective, the results in Table 6.33 shows the perception of the respondents as follows; approximately 98% of the respondents viewed construction cost minimisation as important and extremely important, 91% perceived minimise material wastage as important, approximately 90% viewed simplicity of construction, 85% perceived ease of adaptation, and 83% perceived flexibility in construction as important and extremely important factors influencing their choice of a traditional method for housing construction. Construction cost minimisation thus has the highest mean score value (4.3714), thereby making this factor to be ranked first, followed by material wastage minimisation ranked second with a mean score of 4.3524, simplicity of construction is ranked third (mean score = 4.2857), ease of adaptation and flexibility in construction were ranked fourth and fifth with mean score values of 4.0857 and 4.0381 respectively. To accurately interpret the respondents’ perception of these factors, their opinions on the level of preference to usage of traditional construction methods using the factors as a basis were sought. The results in Table 6.33 shows that approximately 55%, 42% and 33% of the respondents decidedly prefer the traditional method due to simplicity of construction, construction cost minimisation and flexibility in construction respectively. Respondents' perceptions on other factors reveal that the traditional construction method is somewhat preferred, as evident from the results. The value placed on these factors is evident in the mean score values of 2.5333, 2.4095 and 2.3048 ranking them first, second and third. The results of the analysis of factors that influence the respondents' preference of the traditional construction method further corroborate the results of the influence of traditional methods on sustainability. It can, however, be inferred that the ability of general building contractors to execute building projects with less complexities, in terms of construction machinery usage and perceived reduction in cost of construction, and material wastage minimisation, prompted the use of traditional construction methods.

Table 6. 32 Traditional construction method

coding	Factors	Frequency					Mean score	Std. Deviation	Rank
		Extremely not important	Not important	Indifferent	Important	Extremely important			
TCM6	Minimise cost of construction	1%	0%	4.8%	49.5%	48.5%	4.3714	.6687	1
TCM2	Minimise materials wastage	1%	1%	7.6%	42.9%	47.6%	4.3524	.7465	2
TCM1	Simplicity of construction	2.9%	1.9%	5.7%	42.9%	46.7%	4.2857	.8848	3
TCM7	Ease of adaptation	1.9%	2.9%	10.5%	54.3%	30.5%	4.0857	.8333	4
TCM4	Flexibility in construction	1%	1.9%	14.3%	58.1%	24.8%	4.0381	.7458	5
TCM3	Contribute to depletion of natural environment	2.9%	2.9%	19%	52.4%	22.9%	3.8952	.8871	6
TCM5	Require more space for construction activities	9.5%	21%	14.3%	42.9%	12.4%	3.2762	1.2049	7

Table 6. 33 Determinants of traditional construction method preference for housing construction

Coding	Factors	Level of preference			Mean score	Std. Deviation	Rank
		Less preferred	Somewhat preferred	Highly preferred			
TCM1	Simplicity of construction	3.8%	41%	55.3%	2.5333	.6212	1
TCM6	Minimise cost of construction	1.9%	56.2%	42%	2.4095	.5493	2
TCM4	Flexibility in construction	4.8%	61.9%	33.4%	2.3048	.6064	3
TCM7	Ease of adaptation	7.6%	56.2%	36.2%	2.2857	.5999	4
TCM3	Contribute to depletion of natural environment	15.2%	55.2%	29.6%	2.1524	.6762	5
TCM2	Minimise materials wastage	36.2%	33.3%	30.5%	1.9619	.8651	6
TCM5	Require more space for construction activities	27.6%	54.3%	18.1%	1.9143	.6949	7

6.8.3 Extent to which ''Concurrent Engineering'' Supports Sustainability Enhancement in Building Construction

The results in Table 6.34 showed perceptions of general building contractors in South Africa on the use of concurrent engineering construction methods for housing projects. The results showed that approximately 94% of the respondents with a mean score value of 4.4571 ranked elimination of material wastage as the most important factor for using concurrent engineering methods in construction of affordable housing. Similarly, 95% of the respondents perceived reduction in cost of construction as the second most important factor, having a mean score of 4.3714, and faster construction speed ranked third with a mean score value of 4.2095 and supported by approximately 91% of the respondents as important and extremely important. Increase in quality was perceived by 86% of respondent as important and extremely important and was ranked fourth with a mean score of 4.1333. More so, integration of two or more construction methods ranked fifth based on the results of analysis which reveals that 80% of respondents viewed it as important, with a mean score of 4.0857. Other factors were perceived by over 50% of the respondents as equally important in choosing concurrent engineering for housing projects. The results in Table 6.35 show that approximately 66% of respondents prefer using concurrent engineering as a housing construction method due to the high affinity of the method to eliminate materials wastage during construction (mean score of 2.6286). This factor was ranked first and 51% and 44% of the respondents prefer concurrent engineering due to faster construction speed and increase in quality of output. These factors were ranked second and third with mean score values of 2.4762 and 2.4286 respectively. Reduction in cost of construction and integration of two or more construction methods into the construction process were ranked fourth and fifth respectively. These two factors have the same mean score value of 2.4000.

It is worth noting that the results of the analysis have clearly shown that ensuring sustainability in the housing construction process is greatly enhanced through the use of concurrent engineering as a method of construction, which is evident from its ability to minimise cost, eliminate material wastage and the integration of two or more construction methods, among other factors that were rated to have a strong influence as shown in Table 6.34 and Table 6.35.

Table 6. 34 Concurrent engineering construction method

coding	Factors	Frequency					Mean score	Std. Deviation	Rank
		Extremely not important	Not important	Indifferent	Important	Extremely important			
CEM2	Eliminate materials wastages	1.9%	1%	2%	38.1%	56.2%	4.4571	.7724	1
CEM7	Minimise construction expenses	1.9%	1%	1.9%	48.6%	46.7%	4.3714	.7501	2
CEM3	Enhance construction speed	3.8%	1%	3.8%	53.3%	38.1%	4.2095	.8737	3
CEM5	Increase quality	1%	0%	13.3%	56.2%	29.5%	4.1333	.7080	4
CEM1	Promote integration of two or more construction methods	1.9%	5.7%	12.4%	41.9%	38.1%	4.0857	.9518	5
CEM4	Flexibility in construction	1.9%	3.8%	9.5%	61.9%	22.9%	4.0000	.8086	6
CEM6	Minimise use of space for construction	4.8%	12.4%	21%	47.6%	14.3%	3.5429	1.0380	7

Table 6. 35 Determinants of Concurrent engineering construction method preference for housing construction

coding	Factors	Level of preference			Mean score	Std. Deviation	Rank
		Less preferred	Somewhat preferred	Highly preferred			
CEM2	Eliminate materials wastages	2.9%	31.4%	65.7%	2.6286	.5417	1
CEM3	Enhance construction speed	2.9%	46.7%	50.5%	2.4762	.5564	2
CEM5	Increase quality	1%	55.2%	43.8%	2.4286	.5162	3
CEM1	Promote integration of two or more construction methods	11.4%	37.1%	51.5%	2.4000	.6878	5
CEM7	Minimise construction expenses	12.4%	35.2%	52.4%	2.4000	.7016	4
CEM4	Flexibility in construction	4.8%	62.9%	32.4%	2.2762	.5458	6
CEM6	Minimise use of space for construction	2%	48.6%	31.4%	2.1143	.7113	7

6.8.4 Extent to which "Modular Construction'' Supports Sustainability Enhancement in Building Construction

Analysis of perceptions of general building contractors on the use of Modular construction methods for housing projects presented in table 6.36 showed 'Modular construction'' influences on sustainable housing construction. The results in table 6.36 show that approximately 94% of the respondents with a mean score value of 4.5429 rated reductions in duration for construction as the most important factor upon which modular construction is used for affordable housing construction. Conversely, 92% of the respondents perceived elimination of material wastages as the second most important factor, having a mean score of 4.3810, and minimising construction cost was ranked third based on the results of analysis which shows an overwhelming support by 93% of respondents having a mean score of 4.2381. More so, improvement of quality of output and reduction in use of non-renewable materials were ranked fourth and fifth with mean score values of 4.1048 and 4.0857 respectively.

The results in Table 6.37 showed that approximately 75% of respondents prefer to use the modular construction method due to the high level of attraction to reduce production period, eliminate material wastage during construction, rigidity in construction, prevention of pollution and optimization of building design. These factors thus have mean scores of 2.7333, 2.5619 and 2.3619 respectively; hence the factors were ranked first, second and third. It is worth noting that the results of analysis have clearly shown that ensuring sustainability in the housing construction process is somewhat enhanced through the use of modular construction methods, as evident from its ability to eliminate material wastage, faster production rates and reduction in the use of non-renewable materials among other factors shown in Table 6.36 and Table 6.37.

Table 6. 36 Modular construction method

coding	Factors	Frequency					Mean score	Std. Deviation	Rank
		Extremely not important	Not important	Indifferent	Important	Extremely important			
MCM9	Reduce construction time	1%	0%	4.8%	32.4%	61.9%	4.5429	.6797	1
MCM2	Avoid materials wastages	1%	1.9%	5.7%	41%	50.5%	4.3810	.7643	2
MCM6	Minimise cost of construction	1.9%	1.9%	2.9%	57.1%	36.2%	4.2381	.7661	3
MCM7	Improve quality of output	1.9%	1.9%	8.6%	59%	28.6%	4.1048	.7835	4
MCM3	Reduce use of non-renewable materials	1%	1.9%	9.5%	62.9%	24.8%	4.0857	.7086	5
MCM4	Optimise building design	1.9%	4.8%	14.3%	61.9%	17.1%	3.8762	.8168	6
MCM1	Rigidity in construction	1%	10.5%	21%	36.2%	31.4%	3.8667	1.0102	8
MCM8	Prevent pollution	1%	0%	22.9%	63.8%	12.4%	3.8667	.6514	7
MCM5	Minimise use of space during construction	2.9%	16.2%	20%	48.6%	12.4%	3.5143	1.0011	9

Table 6. 37 Determinant for use of Modular construction

coding	Factors	Level of preference			Mean score	Std. Deviation	Rank
		Less preferred	Somewhat preferred	Highly preferred			
MCM9	Reduce construction time	1.9%	22.9%	75.2%	2.7333	.4857	1
MCM2	Avoid materials wastages	2.9%	39%	58.1%	2.5619	.5705	2
MCM1	Rigidity in construction	12.4%	39%	48.6%	2.3619	.6951	3
MCM8	Prevent pollution	6.7%	51.4%	41.9%	2.3524	.6041	4
MCM4	Optimise building design	3.8%	60%	36.2%	2.3333	.5661	5
MCM3	Reduce use of non-renewable materials	9.5%	62.9%	27.7%	2.1905	.6059	6
MCM6	Minimise cost of construction	24.8%	33.3%	42%	2.1810	.8178	7
MCM5	Minimise use of space during construction	13.3%	61%	25.8%	2.1333	.6365	8
MCM7	Improve quality of output	20%	48.6%	31.4%	2.1143	.7114	9

6.8.5 Extent to which "Lean concept'' Support Sustainability Enhancement in Building Construction

Table 6.38 and Table 6.39 present a summary of the descriptive analysis on the extent to which the "Lean construction concept'' influences sustainable housing construction. The results in Table 6.38 showed the perception of the respondents as follows; 98%, 96% and 95% of the respondents viewed; elimination of material wastage, minimisation of negative impact of construction on the environment, and construction cost minimisation as important and extremely important. These factors have mean score values of 4.6095, 4.5333 and 4.3905 respectively, thereby ranking them first, second and third. Similarly, improved quality and enhanced flexibility in construction were ranked fourth and fifth with mean values of 4.2952 and 4.2476. However, to ensure correct judgement on the perception of the respondents on these factors, opinions on the level of preference to usage of lean construction concepts using the factors as a basis were determined, and the results in Table 6.38 show that approximately 99%, 96%, 99%, 98% and 99% of the respondents highly prefer the lean construction concept, due to the elimination of material wastage, flexibility in construction, construction cost minimisation, minimisation of negative impact of construction on the environment, and improved quality of housing respectively. Respondents' perceptions on other factors reveal that the lean concept is somewhat preferred as evident in the results. The value placed on these factors is evident from their respective mean score values of; 2.7619, 2.7524, 2.7238, 2.5905 and 2.5333 ranking them first, second, third, fourth and fifth among the factors that influenced respondents' choice of lean construction concept for housing projects.

The results of the analysis of factors that influence respondents' preference for the lean construction concept further confirms that lean concepts have a great influence on construction of sustainable housing development.

Table 6. 38 Lean construction

coding	Factors	Frequency					Mean score	Std. Deviation	Rank
		Extremely not important	Not important	Indifferent	Important	Extremely important			
LCC2	Avoid materials wastages	1%	0%	1%	33.3%	64.8%	4.6095	.6123	1
LCC1	Minimise negative impact on the environment	1%	1%	1.9%	36.2%	60%	4.5333	.6803	2
LCC6	Minimise cost of construction	1%	1%	2.9%	48.6%	46.7%	4.3905	.6863	3
LCC3	Improve quality of output	1%	0%	5.7%	55.2%	38.1%	4.2952	.6639	4
LCC4	Enhance flexibility in construction	1%	1%	5.7%	57.1%	35.2%	4.2476	.6903	5
LCC7	Ease of adaptation	1%	1.9%	8.6%	51.4%	37.1%	4.2190	.7593	6
LCC5	Minimise use of space during construction	1%	11.4%	10.5%	56.2%	21%	3.8476	.9175	7

Table 6. 39 Lean construction preference determinant

coding	Factors	Level of preference			Mean score	Std. Deviation	Rank
		Less preferred	Somewhat preferred	Highly preferred			
LCC2	Avoid materials wastages	1%	21.9%	77.1%	2.7619	.4498	1
LCC4	Enhance flexibility in construction	3.8%	45.7%	50.5%	2.7524	3.0343	2
LCC6	Minimise cost of construction	1%	25.7%	73.3%	2.7238	.4701	3
LCC1	Minimise negative impact on the environment	1.9%	37.1%	61%	2.5905	.5316	4
LCC3	Improve quality of output	1%	44.8%	54.3%	2.5333	.5201	5
LCC7	Ease of adaptation	4.8%	46.7%	48.6%	2.4381	.5871	6
LCC5	Minimise use of space during construction	11.4%	49.5%	39%	2.2762	.6577	7

6.8.6 Effects of Construction Methods on Cost of Construction and Housing Sustainability

Sustainable construction is conceived to restore and maintain harmony between the natural and built environment, while creating human settlements that affirm human dignity and encourage economic equity. However, to achieve the creation of sustainable settlements, adequate attention has to be given to the utilisation of building material during housing construction. Therefore, to ascertain the most appropriate construction method, respondents were asked to rate their overall perceptions of the construction methods as they influence cost of construction and sustainability enhancement in housing construction. The results of the analysis presented in Table 6.40 revealed the ranking of the construction methods as they influence cost of construction and sustainability.

From the results, concurrent engineering ranked first, modular construction ranked second, the lean concept ranked third and traditional construction ranked fourth, based on their influence on cost of construction. On influence of the construction method on sustainability, the lean concept ranked first, modular construction ranked second, concurrent engineering ranked third and traditional construction ranked fourth. Therefore, it is essential to conduct further investigation to ascertain the nature of the effects of these construction methods on cost and sustainability. Pearson correlation analysis was performed to achieve this task.

Table 6. 40 perceived influence on cost and sustainability

Coding	Construction method/concept	influence on cost of housing			influence on sustainability		
		Mean score	Std. Deviation	Rank	Mean score	Std. Deviation	Rank
CM1	Traditional construction method	3.2952	0.795	4	2.9429	1.026	4
CM2	Concurrent Engineering	3.9905	0.727	1	3.2095	0.997	3
CM3	Modular construction	3.8381	0.637	2	3.8952	0.634	2
CM4	Lean concept	3.5524	0.772	3	4.1810	0.731	1

Correlation is an essential technique to describe the strength and direction of relationships between variables. The results of Pearson correlation displayed in Table 6.41 showed that there is a significant relationship between the influence of the traditional construction method on construction cost and influence of concurrent engineering on sustainability. These variables exhibited a very strong relationship at 99% significance level. The result also shows that the Lean concept and Modular construction have a very strong correlation at 99% alpha level. Therefore, it can be inferred from the relationship exhibited by these construction methods that combining the traditional method and concurrent engineering method on a project will enhance realisation of sustainable affordable housing. More so, Modular construction and Lean concepts could be integrated on a project to realise sustainable housing construction.

Table 6. 41 Ascertaining construction methods for sustainable construction

		Traditional Method (sustainability)	Modular Construction (sustainability)	Concurrent Engineering (sustainability)	Lean Concept (sustainability)
Traditional Construction Method influence (cost)	Pearson Correlation	.350**	.236*	.290**	.040
	Sig. (2-tailed)	.000	.015	.003	.689
	N	105	105	105	105
Modular Construction Method (Cost)	Pearson Correlation	.115	-.103	.206*	.311**
	Sig. (2-tailed)	.242	.294	.035	.001
	N	105	105	105	105
Concurrent Engineering Construction (Cost)	Pearson Correlation	.030	.235*	.195*	.229*
	Sig. (2-tailed)	.763	.016	.046	.019
	N	105	105	105	105
Lean Construction Concept (Cost)	Pearson Correlation	.125	.260**	.198*	.179
	Sig. (2-tailed)	.203	.007	.043	.068
	N	105	105	105	105

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

6.9 IDENTIFYING SOCIAL FACTORS THAT ENHANCE SUSTAINABILITY IN HOUSING CONSTRUCTION

Sustainability encompasses balancing the environmental, social and economic attributes in the creation of the built environment, that enhances healthy living of the occupants. In order for a building, i.e. the construction product, to fulfil the demands of sustainability, social indicators must be assessed in relationship with the construction project. This section therefore evaluates some social sustainability factors as they affect the planning stage, design stage and construction stage in the building development process. These social indicators include, but are not limited to; stakeholders' engagement, impact of the project on cultural values, average household size, health and safety, community interaction, operating cost of the building, protection of natural habitat, employment opportunities for the people and social equity. The choice of these indicators is however a reflection of the stakeholder's interests and the objective of housing.

6.9.1 Social Sustainability Indicator at Inception Stage of Housing Project

The results of analysis in Table 6.42 show the perception of respondents on the social sustainability factor at the inception stage of a housing construction project. The results showed that the importance attached to infrastructure development by construction professionals at the planning stage of a housing project was high, with approximately 97% of the respondents saying infrastructure provision is an important issue to enhance sustainability in affordable housing. On the importance attached to household size at the inception stage of a housing project, 94% of the respondents were of the view that it is an importance factor which must be accorded due consideration. Approximately 90% of the respondents perceived stakeholder engagement at the inception stage as a priority task. Health and safety, local community status and considering the cultural belief were perceived as important factors by 93%, 76% and 55% of the respondents respectively.

Summarily, the results show that infrastructure development is vital to housing provision to promote a healthy living for the people. This factor thus has a mean score value of 4.5714 and was ranked first being the most important social indicator factor at the inception stage of a housing project. Household size with a mean score of 4.5619 ranked second, stakeholder engagement with mean score value of 4.2762 ranked third and health and safety ranked fourth with mean score value of 4.1048.

Table 6. 42 Social sustainability factors at inception stage of housing project

coding	Factors	Frequency					Mean score	Std. Deviation	Rank
		Extremely not important	Not important	Indifferent	Important	Extremely important			
SSI6	Infrastructural development inception	0	0%	2.9%	37.1%	60%	4.5714	.5522	1
SSI4	Household size	0	0%	5.7%	32.4%	61.9%	4.5619	.6033	2
SSI1	Stakeholders engagement	3.8%	2.9%	3.8%	41%	48.6%	4.2762	.9557	3
SSI5	Health and safety	1%	1.9%	3.8%	72.4%	21%	4.1048	.6343	4
SSI3	Local community status	1%	2.9%	20%	57.1%	19%	3.9048	.7662	5
SSI2	Cultural impacts at inception	13.3%	15.2%	16.2%	31.4%	23.8%	3.3714	1.3535	6
SSI7	Corporate social responsibility inception	5.7%	44.8%	23.8%	20%	5.7%	2.7524	1.0264	7

In addition to information sought from the respondents on their perceptions of the social sustainability factors at the inception stage of housing, a follow up on who should be responsible for executing the task of providing social indicators factors at the inception stage was sought from the research participants. The results in Table 6.43 showed that government is to be saddled with the responsibility of providing infrastructure which include electricity, rails, roads, educational facilities and medical facilities, and engaging the stakeholders (beneficiaries of the proposed housing). These two factors ranked first and third as shown in Table 6.42. While household size (second ranked factor) and Health and safety (fourth ranked factor) were allocated to the consultant and Designers, since the household size as a factor involves critical analysis of the average size of a household in the community and the population of the people living in such a community. The health and safety involves assessment of potential health and safety risk to the public and the intended user of the project. This result is corroborated by Li, et al. (2014) who opined that social and humanistic needs should focus on convenient public facilities and services, compatibility of buildings with the sur-rounding environment, the rationality of layout and functions, as well as the adaptability to local climate. However, personal and property safety issues related to household residential conditions, functional and psychological needs of different groups local historical and cultural features are not of great concern.

Table 6. 43 Allocation of social responsibility to project parties at inception stage

Coding	Factors	Frequency of allocation			Mean score	Std. Deviation	Decision on allocation
		Government	Consultant & Designer	Contractor			
SSI1	Stakeholders engagement	80%	16.2%	3.8%	1.2381	.5099	Government
SSI2	Cultural impacts at inception	69.5%	26.7%	3.8%	1.3429	.5517	Government
SSI3	Local community status	58.1%	37.1%	4.8%	1.4667	.5894	Government
SSI4	Household size	27.6%	70.5%	1.9%	1.7429	.4809	Consultant & designer
SSI5	Health and safety	11.4%	77.1%	11.4%	2.0000	.4804	Consultant & designer
SSI6	Infrastructural development inception	81%	12.4%	6.7%	1.2571	.5723	Government
SSI7	Corporate social responsibility inception	11.4%	19%	69.5%	2.5810	.6903	Contractor

6.9.2 Social Sustainability Indicator at Design Stage of Housing Project

The study further examines the construction professionals' perceptions on the importance accorded the identified social sustainability indicators at the design stage of a housing project. The result reveals "building operation cost", which is defined as a process through which the reduction in operational cost of the building to the user could be achieved either through provision of some basic equipment or otherwise, was rated as the most important social factor being considered during the design stage of a housing project. The factor was rated by approximately 100% of respondents as an important factor, the factor is thus ranked first with a mean score of 4.5048. Protection of natural habitat was rated as the second most important factor by 96% of the respondents, with a mean score value of 4.4571. Protection of natural habitat is defined in this study as "protecting the biodiversity of the surrounding natural habitat which influences the socio-economic activities of the people". Stakeholder engagement was rated as an important factor by 94% of the research participants, and was ranked third (mean score = 4.3905). Sense of communal interaction (i.e. provision of facilities that encourages social activities and human interactions) was ranked fourth with a mean value of 4.1810, rated as important factor by 94% of the respondents. More so, considering cultural needs, and health and safety were ranked as the fifth and sixth most important factors.

Table 6. 44 Social sustainability factors at design stage of housing project

coding	Factors	Frequency					Mean score	Std. Deviation	Rank
		Extremely not important	Not important	Indifferent	Important	Extremely important			
SSD6	Building operation cost	0%	0%	0%	49.5%	50.5%	4.5048	.5024	1
SSD7	Protection of natural habitat	0%	1%	2.9%	45.7%	50.5%	4.4571	.6049	2
SSD1	Stakeholder engagement	2.9%	0%	2.9%	43.8%	50.5%	4.3905	.8026	3
SSD4	Sense of communal interactions	0%	1%	4.8%	69.5%	24.8%	4.1810	.5509	4
SSD3	Considering cultural needs	1%	0%	8.6%	61.9%	28.6%	4.1714	.6572	5
SSD5	Health and safety	0	1%	4.8%	80%	14.3%	4.0762	.4743	6
SSD2	Social equity	0	1%	15.2%	67.6%	16.2%	3.9905	.5964	7
SSD8	Public accessibility	1.9%	4.8%	33.3%	47.6%	12.4%	3.6381	.8335	8

To successfully implement social sustainability indicators in construction of affordable housing, tasks must be specifically allocated to appropriate parties in the project, to ensure strict compliance. Hence, the respondents were asked to allocate the implementation of social sustainability factors amongst the parties in a housing project, in this case government, consultants and designers and contractors. However, the results of the analysis in Table 6.45 showed that "building operation cost" which ranked first was allocated to consultants and designers. The decision to allocate implementation of this task was based on the opinion of 85% of the respondents. The second most ranked factor "protection of natural habitat" was assigned to government as implementation medium, as viewed by approximately 60% of the respondents. Stakeholder engagement and sense of communal interaction at the design stage was to be effected by consultants and designers, having been supported by 71% and 80% of the respondents respectively.

Table 6. 45 Social sustainability responsibility allocation at design stage

Coding	Factors	Frequency of allocation			Mean score	Std. Deviation	Decision on allocation
		Government	Consultant & Designer	Contractor			
SSD1	Stakeholder engagement	27.6%	71.4%	1%	1.7333	.4655	Consultant & designer
SSD2	Social equity	44.8%	52.4%	2.9%	1.5810	.5509	Consultant & designer
SSD3	Considering cultural needs	7.6%	89.5%	2.9%	1.9524	.3217	Consultant & designer
SSD4	Sense of communal interactions	14.3%	80%	5.7%	1.9143	.4410	Consultant & designer
SSD5	Health and safety	11.4%	80%	8.6%	1.9714	.4484	Consultant & designer
SSD6	Building operation cost	4.8%	84.8%	10.5%	2.0571	.3880	Consultant & designer
SSD7	Protection of natural habitat	60%	30.5%	9.5%	1.4952	.6668	Government
SSD8	Public accessibility	49.5%	23.8%	26.7%	1.7714	.8464	Government

6.9.3 Social Sustainability Indicator at Construction Stage of Housing Project

As revealed in the results of analysis on social sustainability indicators at the construction stage in Table 6.46, use of local materials and human resources (labour) was ranked first (mean score = 4.6095), evident from the perception of 97% of the respondents. This overwhelming support was unconnected with the fact that using locally available materials and labour will not only enhance project success, but will influence positively on the economic well-being of the people. Employment opportunity was rated the second most important social sustainability factor (mean score: 4.5238) as 97% of the respondents rated the factor as important. At the construction stage, community participation was also accorded as important and ranked third with a mean score of 4.5048, and health and safety ranked fourth (mean score = 4.1905) with a percentage frequency of 98% of the respondents who perceived health and safety as important social indicator. Other indicators, such as equitable social service and social-economic upliftment of the project staff, were rated fifth and sixth respectively.

Table 6. 46 Social sustainability factor at construction stage

coding	Factors	Frequency					Mean score	Std. Deviation	Rank
		Extremely not important	Not important	Indifferent	Important	Extremely important			
SSC2	Use of local resources	1%	1%	1%	30.5%	66.7%	4.6095	.6577	1
SSC1	Employment Opportunity	1%	0%	1.9%	40%	57.1%	4.5238	.6369	2
SSC5	Community participation	1%	0%	2.9%	40%	56.2%	4.5048	.6523	3
SSC7	Health and safety in construction	0%	1%	1%	76.2%	21.9%	4.1905	.4823	4
SSC3	Equitable social services	1%	1%	4.8%	68.6%	24.8%	4.1524	.6322	5
SSC4	Socio economic upliftment	1%	1%	9.5%	75.2%	13.3%	3.9905	.5964	6
SSC6	Minimising neighbourhood disturbances	1%	4.8%	23.8%	61%	9.5%	3.7333	.7373	7
SSC8	Enhancing job satisfaction	1.9%	4.8%	31.4%	48.6%	13.3%	3.6667	.8397	8

The results of analysis in Table 6.47 reveal that one out of the four rated most important social indicators at construction was allocated to “consultants and designers”, while the others were allocated to contractors for implementation. Allocation of the use of local resources to consultants and designers was supported by 58% of the respondents. Allocation of employment opportunity, community participation, and health and safety to contractors was supported by 69%, 66% and 80% of the respondents respectively.

Table 6. 47 allocation of social responsibility at construction stage

Coding	Factors	Frequency of allocation			Mean score	Std. Deviation	Decision on allocation
		Government	Consultant & Designer	Contractor			
SSC1	Employment Opportunity	20%	11. 4%	68.6%	2.4857	.8099	Contractor
SSC2	Use of local resources	7.6%	58.1%	34.3%	2.2667	.5926	Consultant & designer
SSC3	Equitable social services	29.5%	43.8%	26.7%	1.9714	.7526	Consultant & designer
SSC4	Socio economic upliftment	20%	16.2%	63.8%	2.4381	.8077	Contractor
SSC5	Community participation	9.5%	23.8%	66.7%	2.5714	.6629	Contractor
SSC6	Minimising neighbourhood disturbances	1.9%	15.2%	82.9%	2.8095	.4406	Contractor
SSC7	Health and safety in construction	2.9%	17.1%	80%	2.7714	.4855	Contractor
SSC8	Enhancing job satisfaction	5.7%	9.5%	84.8%	2.7905	.5316	Contractor

6.10 Summary of Chapter Six

This chapter presents and discusses the results of analysis on the quantitative phase of this research using descriptive and inferential statistics. The results affirm the hypothesised statements within the study. The findings showed that RSA construction professionals place greater value on environmental consciousness when conceptualising housing projects. The biggest concerns of the construction industry as regards its activities are water pollution, population growth, depletion of renewable resources, global warming, and deforestation, among other factors. The results of analysis on housing satisfaction identified use of energy saving building materials and socio-economic attributes as the factors that enhance user satisfaction in housing. These factors were found to have an influence on the achievement of sustainable construction. The perceived impediments to full adoption of sustainable construction, according to the results of analysis, were maintenance concern, fear of extra cost being incurred, and difficulties in balancing social and environmental issues. The study also identifies four housing financing systems as the most appropriate mode of financing housing projects to enhance sustainable construction. Also, the analysis identifies a basic project goal upon which sustainability of a construction project could be measured before such a project is adjudged sustainable construction. The results of analysis on construction methods revealed that the Lean concept and Modular construction have a strong correlation, while Traditional construction and Concurrent engineering are related. This study thus asserts that to enhance sustainability in housing construction, the combination of these methods is very essential.

CHAPTER SEVEN
QUALITATIVE DATA ANALYSIS

7.1 INTRODUCTION

This chapter contains the analysis of qualitative data across individual cases to identify and establish similarities and differences in the strategy employed when planning for affordable housing construction, with respect to environmental, socio-economic sustainability and construction method (technology and innovation). By establishing the convergence and discrepancies, the study intends to provide further in-depth understanding of the constructs and to validate the results of the quantitative analysis reported in Chapter 6 of this thesis. In Chapter 5, the study presents and contends the significance of the qualitative strand in order to make significant and good judgement of the empirical study, and to validate the study conceptual framework. In Chapter 5 (section 5.4.4.1) the qualitative data collection approach adopted in this research was reported. The study therefore uses multiple case studies, which allow a researcher to build an analytical string of evidence. The data was analysed using explication techniques to examine each case, and cross case was utilised to search for a string of evidence for interconnectivity among the constructs based on the model.

7.2 QUALITATIVE DATA ANALYSIS

Extant literatures have reported the existence of several techniques for analysing qualitative data, for example, Madill and Gough (2008:258) suggest categorisation procedures; categorised methods of analysing qualitative data into four: discursive, thematic, structured and instrumental. Fellows and Liu (2008:189) suggest content analysis being the most simplistic and cautioned method, that sound, theoretical understanding of the issue is important to assist the researcher in development and testing of a hypothesis. Yin (2009:174) supports and expands the categorisation by Madill and Gough (2008) by regrouping the techniques into five; pattern matching, explanation building, time-series analysis, logic models and cross-case syntheses. Blaxter, Hughes and Tight (2006), propose an explication technique, which comprises of five phases: bracketing and phenomenological reduction; delineating units of meaning; clustering of units of meaning to form themes; summarising each interview, validating and where necessary modifying it; and extracting general and unique themes from all the interviews and making a composite summary.

Consequently, the study makes use of the explication technique proposed by Blaxter, *et al.* (2006). The recorded interviews were transcribed and coded using an Excel spreadsheet for effective management of the data. The main essence of coding is to provide an obvious interpretation of the issues to be derived from the interviews (Blismas & Dainty, 2003:460). After the coding was completed, large amounts of data were separated from the raw data, which enhances the closeness of the researcher to the data gathered. Thereafter, the data was further broken down to search for themes, which were subsequently reviewed, described and named (Bowen, Edwards & Cattell, 2012:889). This formed the foundation for establishing the constructs that influence the enhancement of sustainability in affordable housing construction. Thus, in presenting each case study findings, a structural approach was used by giving a synopsis of the general background information to each individual case, presenting the findings from individual case analysis and giving a composite summary of the cross-case analysis.

7.3 CASE STUDY ANALYSIS

7.3.1 Case Study 1

7.3.1.1 Background information of Organisation A

Organisation ‘A’ was established in 1918 as a housing development company to develop towns and suburbs around the city of Cape Town at the inception, and later expanded its operations to other provinces of South Africa. The company’s core operation is residential housing development. It was established as a private property development company and the company is a leading private property development company that has entered into partnership with RSA government in affordable housing construction. The company is owned by white, black and coloured. The organisation has a cidb grading of 7GB (General Building), which enables the company to tender on wide range of value contracts on offer in its field of expertise. The company is currently on BBBEE Level 2 and it operates throughout RSA.

7.3.1.2 Environmental Sustainability Consideration

To establish how environmental sustainability considerations influence the company decisions as regards the housing projects executed by it, the Project Manager of organisation ‘A’ was interviewed on environmental sustainability influences on the decision-making process, and its application to; building design, building material selection, construction method and construction waste management. In addition, questions were asked about the influence of the company practices on the acceptability of the houses built by the company. The respondent demonstrated that environmental consideration is given priority in all her projects. The respondent stated that the implementation of decisions regarding environmental consideration factors affecting building design, material selection and the like, are done based on the discretion of individual staff, whoever is incharge of the execution of a particular project.

> *“I would say that our company design decision is largely influenced by the nature of building materials we intend to use in conformity with government specification, though the materials specifications on our company private housing development are based on life-cycle assessment of the building materials. As regards government affordable housing, we build in conformity with government laid down specification, we don’t change it because if we make any changes the government is going to reject the project which might lead to litigation and all of that”.*

When asked on the acceptability of the affordable housing the company is constructing in partnership with the government by the target user:

> *“This land is not government land, it’s our land. We told the community that this is the type of houses we have agreed with government to build here and we only take the subsidy-payment from government if you want the house and if you don’t want the house we sell it and the government will probably go find another land to build on”.*

The interviewee also contends that the company approach to affordable housing is “push to user approach” and not “user-pull approach”. That is, the houses are built based on government decision, not minding what the people want.

7.3.1.3 Housing Finance

The Project Manager of organisation ‘A’ describes the financing scheme used by the company to finance its private housing projects as largely mortgage finance, and government housings were built through “Housing Subsidies”. The respondent stressed that it is very expensive to build affordable housing with mortgage loans from commercial institutions but it is cheaper to build through subsidies. Although, the respondent expressed worries over illegal sales of the government affordable housing below the prevailing market price. The respondent stated that:

"……. my view to the Government if a person want to sell his/her BNG house for ZAR30,000 the government should buy the house and create a market for resale of such house. You know why I take another BNG guy and put him in the house instead of keeping people on the waiting list. I don't understand why the government allow informal trading with ZAR30,000 to continue and build with ZAR165,000, until the marketability of this houses comes up to the real value then this whole thing is a broken process". I think some other financing scheme that will make it mandatory for beneficiary of this house to contribute to the cost of construction must be employed by government".

However, the respondent thus affirms the need to employ other techniques through which affordable housing could be financed to encourage construction of houses that are user-demanded.

7.3.1.4 Social-economic Sustainability

Socio-economic analysis of a housing project is significant in determining whether community engagement, assessment of available infrastructure at the project site, assessment of building operation cost, introducing features to suit the traditional/spiritual need of the target user, consideration of the average household size in housing design, provision of facilities that encourages social activities and human interactions in the community, and engaging the labour within the community among other socio–economic factors influence achievement of the project objectives. The respondent asserts that the company placed greater importance to users' welfare through provision of basic infrastructure, community engagement and empowerment, and delivery of better quality BNG housing.

"I think we are delivering a better house, we know in summer when you stand in this house is cool and in winter you standing inside its warm. This house that is standing now was built in January and we have not receive crack on it, as far as we are concern we have been building for close to 100 years and we cannot build houses that we will start receiving complaints in the next 20 years and we got to maintain our records. This house can be extended to the back depending on the choice of the occupant we leave about 8 meter space at the back for such extension to take place".

When asked about the mechanism the company does employ to ensure effective maintenance of towns built by the company;

"…….. we are worried about our towns, we build most of the suburbs in Cape Town, Durban and Johannesburg we put schools, sport field, parking arears, malls, etc. and our view on the township is that; it must look nice and the problem in all the ones they are building now is that you set the house back they build shack in the front and when that happens, people will not want to buy the house, we belief by putting the house close to the road, it will force the occupant to put all the rubbish at the backyard. To encourage cleanliness of the environment, we are going to be doing competition every month for best person that keep its environment clean".

From the interviewee response, it became obvious that sustainable affordable housing cannot be achieved in an environment where there is infrastructural deficit and the local community was not engaged at both the planning and construction stage of the project.

7.3.1.5 Technology and Innovation

In order to establish the strategy employed by the company to achieve sustainable construction in the affordable housing constructed by the company, the respondent explained that his company have been employing some innovative technology in the houses constructed by the company.

"the unique thing in this house is that, it is new building technology, the foundation is Raft with "Plastic Dome" with an 80mm slabs, the blocks are lightweight blocks when compare to the weight of normal construction. There is polystyrene in the block, its 4-hours Rated sound insulation and 37 SA hours value for thermal of 0.52 which is the same as Clay Brick, and it is twice that of normal concrete block., The block does not absorb water, so no water rising through the wall and in terms of delivery when you look at the embedded energy in the house this house, it is probably about 60% more than conventional house and the Roof is a composite roof with the ceiling. The insulation of the roof in one product, it is put in straight as single product. These two houses from start to finish the two together it's about 15-working days. the slab that we also have is about 80mm thick, it's a Raft and got mesh and steel in it and it got down-stand beam on the outside walls. The block has two sides as you can see, you can just see the polystyrene at the edges here and you can see the smooth side of the block here, for the lintel cement fiber new-check board is used and it was for this project to satisfy the new SANS regulation to provide shadings to the window".

The respondent was asked on the waste reduction strategy employed by the company to reduce material wastage;

> *"the block that we use is specially molded, you see here including the one in the house the off-cut is less than 1-percent instead of 10% on a normal block also the block comes with a spacer. When you cut the block, you don't throw it away because you still need the off-cuts somewhere in the building. We are using bedding powder instead of cement for bedding, one bag of the bedding powder is mix with placing-gun and it covers 10m^2 and in a house we use about 20-bags of bedding-powder. The system laid the block faster and reduces "wastages" because there are no people carrying mortar around during the construction, it gives a very clean process".*

The respondent was also confronted with questions on measures to ensure affordability of the houses:

> *"Considering the overall costing, this block cost about ZAR28 when a normal block costs ZAR15. When you add up all the input, the house is not cheaper, but its fast to construct and reduce wastage. The plastic domes (cobute), form little beam and you end-up with thin concrete topping and give a kind of waffle arrangement and this thus bring the concrete down to about 80mm from 110mm. The only problem is the supplier charges so much money for the plastic dome. The cost of foundation for this building is cheaper, but standard raft might cost a little more but its faster. When we do the cost-benefit analysis, considering; time and cost process, we see that the plastic dome does not add value to the building".*

The respondent also asserts that it is expensive to build a unit of the housing considering the construction method and building materials used for the project, but the benefits are that delivery rate is faster and better quality is achieved which in the long-run will nullify the additional cost incurred during construction.

> *"……..on this house there is not a lot of suppliers so we got the concrete and steel supplied to the foundation, we got the blocks coming from our factory, windows and doors will come from one supplier and the roof and ceiling will come from one supplier and electrical and plumbing will follow. All the plumbing and electrical item will be delivered in boxes for each house so we haven't got 100 and 100's of suppliers and we will have building merchant like a warehouse where we could put the miscellaneous/sundries items like screws, nails, saws and so on. We keep our supply chain to very view people and again it means we do not rely on dozens and*

dozens of people. In all we have only 3-trade in 3-contractors, and that is where the whole time and process is accelerated. It is quicker and also less materials and it does not give room for people to steal materials easily because we don't rely on many contractors. That is where the benefit is but again I want to reiterate that the house is not cheaper, it is a better building, the insulation value, sound value and etc is better but it does not come with better cost and even though we are reducing the labour".

On the specific method of construction, the respondent described the method of construction as "Modular construction" though some aspects of the process are done using the conventional (traditional) construction approach.

7.3.2 CASE STUDY 2

7.3.2.1 Background information of Organisation B

Organisation 'B' was established in 1984 as a Cape based Construction Company with expert knowledge on road and building construction. In 1995, the organisation extended its operations to other provinces of South Africa. The company core operations in its building section are; Industrial building, commercial building and residential housing development. The company is owned by white, black and coloured. The organisation has a cidb grading of 9GB (General Building) and 9CE (Civil Engineering), which enables the company to tender on a wide range of value contracts on offer in its field of expertise. The company is currently on BBBEE Level 2 and it operates throughout RSA, and has entered into partnership with RSA government in construction of affordable housing to curb the housing challenges facing the country.

7.3.2.2 Environmental Sustainability Consideration

The Building Project Controller of organisation 'B' was interviewed on how environmental sustainability influences the company decision-making process on affordable housing, and its application to; building design, building material selection, construction method and construction waste management. The respondent demonstrated that environmental consideration is given priority in all the company projects. The respondent stated that decisions to implement environmental consideration factors affecting building design, material selection and the like, are done based on the client's specification, since the company is a contracting organisation.

In addition, a question was asked about the influence of the company practices on the acceptability of the houses build by the company.

"I would say that our company design decision is largely influenced by the nature of building materials specification for the project, we are using normal standard Brick and mortar in affordable housing that we build, as I said earlier we tendered for the project and its normal brick and mortar the tender specify, we don't change it because if we make any changes it will be against our contract agreement with government".

The respondent was questioned on the efforts of the company towards mitigating the effects of its activities in depleting natural resources:

"the work comes through tender and the tender specify what we must do, we are not responsible for the design at the moment and we are not using any alternative building methods. There is a lots of alternative building methods in the country and in other country we are not using any of them we only build with brick and mortar".

When asked on the acceptability of the affordable housing the company is building in partnership with the government by the target user:

"We do get involved with the community our Chairman is doing that, on our previous housing projects people were involved and the people were happy with the project".

The interviewee contends that the company approach to affordable housing is based on government decision, though as a contractor, the company always involves the local community in the construction work.

7.3.2.3 Housing Finance

The organisation 'B' Project Controller describes the financing scheme used by the company to finance housing project as largely through government "Housing Subsidies". The respondent stressed that it is cheaper to build through subsidies and suggested that government must find a way to stop the illegal sale of the houses below the prevailing market price that has bedevilled the affordable housing market.

"……. the education process for people on the cost of the house is essential, people must be told that the house costs ZAR165,000, it will be stupid to sell the house at ZAR30,000 or even ZAR40,000".

The respondent asserts the need for government to engage in a continuous awareness to sensitise the people on the value of the house to discourage illegal sale of the house below its market worth.

7.3.2.4 Social-economic Sustainability

Questions were asked on socio-economic analysis of a housing project in determining whether community engagement, assessment of available infrastructure at the project site, assessment of building operation cost, introducing features to suit the traditional/spiritual need of the target user, consideration of the average household size in housing design, provision of facilities that encourages social activities and human interactions in the community, and engaging the labour within the community, among other social–economic factors, influence the company to achieve the project objectives. The respondent asserts that company placed greater importance to users' welfare through provision of basic infrastructure, community engagement and empowerment, in delivery of better quality BNG housing.

> *"…… you must remember one thing, there must always be land to build on and land doesn't last forever, if you take the CBD, the CBD is fully built and there must be infrastructure before you can build on any land. I think that is one of the problem government is facing because you can build low-cost houses too far away from CBD, how will people get to work. For us as a company all our housing projects are built closer to where people can have easy access to transport to work, though it influence the cost of land significantly ……"*

From the interviewee's response, it became obvious that sustainable affordable housing cannot be achieved in an environment where there is infrastructural deficit and the local community was not involved at the construction stage of the project.

7.3.2.5 Technology and Innovation

The interviewee was asked about the strategy employed by the company to achieve sustainable construction in the affordable housing constructed by the company, the respondent explained that his company builds to government specification.

> *"…… I said we build to tender, brick and mortar is specified and we build with it. Though no company got any programme to see if brick and mortar is sustainable or it will last for 100 years, but brick and mortar I can say is sustainable because RSA is brick and mortar country though nothing lasts forever and there are buildings that have lasted over 20 to 50 years, but if the Department of Human*

settlement put out tender and they recommend alternative materials will build with".

The respondent was asked on the waste reduction strategy employed by the company to reduce material wastage:

"…. the brick that we use is specially molded, for our projects, so the off-cut is less than 3 percent. We're using skilled workers trained by our company, they laid the brick faster and reduce wastages".

On the specific method of construction, the respondent described the method of construction as "Traditional construction" approach.

"in RSA, all the people want brick and mortar and there is lots of resistance towards alternative building methods, honestly, RSA is not like Europe where they got alternative building for years and years and in America they do paneling with wood and rest of them but RSA is brick and mortar which goes basically with traditional construction method".

7.3.3 CASE STUDY 3

7.3.3.1 Background information of Organisation C

Organisation 'C' (the Department of Human Settlement in Province V) came into being in 1994 after the dawn of democracy. The roots of DoHS can be traced back to 1956 when the Freedom Charter was adopted in Kliptown, the founding base for the department is the clause that says: "there shall be houses, security and comfort for all in South Africa". Also the Constitution of the Republic of South Africa (1996) states that access to housing is a basic human right, and the government has to provide an environment conducive to progressive realisation of the right. The interviewee is a Regional Project Manager in the DoHS in Province V. Based on the mandate of the DoHS, questions were asked on the provision of affordable housing within the scope of sustainable development.

7.3.3.2 Environmental Sustainability Consideration

To establish how environmental sustainability considerations influence the organisation decisions as regards the housing projects initiated by the DoHS, the Regional Project Manager of organisation 'C' demonstrated that environmental consideration is given priority in all housing projects. The respondent stated that decisions to implement environmental consideration factors affecting building design, material selection and the like, are done based on the DoHS policy and specification, as it affects all building elements and location.

In addition, a question was asked about the acceptability of the affordable houses delivered to the people.

> *"I would say that the design decision is largely influenced by the nature of building materials and specification for the project. As of now, we are using normal standard brick and mortar in affordable housing that we rollout to the public. This material is used because our people prefer it to other alternative building materials".*

When asked on the acceptability of the affordable housing delivered in partnership with the private housing developers, the respondent stated that:

> *"We do get involved with the community at the planning stage of housing projects to engage with them on a number of issues such as census taken of eligible beneficiaries, we use age limit and the number of dependents. Our engagement with the community is largely in line with government policies in place as a result most of the user request don't count".*

The interviewee contends that the DoHS approach to affordable housing is based on policies directions of RSA national government.

7.3.3.3 Housing Finance

The organisation 'C' Regional Project Manager describes the financing scheme used by the organisation to finance housing project as largely through government "Housing Subsidies".

> *"……. The department is a funding agency for affordable housing projects. At the moment what we use is basically housing Subsidies and what we are interested in is to provide free housing to the people. Yes using some other financing method is very necessary because that is going to make the community engagement be a viable input in our decision-making. Another programme that we have to finance housing for those outside the cost-band for affordable housing are captured under 'Integrated residential development programme' in which these category of people are made to pay top-ups".*

The respondent acknowledged the difficulties in curbing the illegal transfer of ownership of the houses, which is the norm in the affordable housing sector at the moment. He suggested the need to employ other housing financing models that will encourage community based construction in the planning and construction of affordable housing.

7.3.3.4 Social-economic Sustainability

Questions were asked on socio-economic analysis of a housing project in determining whether community engagement, assessment of available infrastructure at the project site, assessment of building operation cost, introducing features to suit the traditional/spiritual need of the target user, considering the average household size in housing design, provision of facilities that encourages social activities and human interactions in the community, and engaging the labour within the community, among other socio–economic factors, influence the company to achieve the project objectives. The respondent asserts that the DoHS placed greater importance to users' welfare through provision of basic infrastructure, community engagement and empowerment, delivering of better quality BNG housing.

> *"…… at the moment we are implementing informal settlement upgrading, whereby we look at the social and economic activities of the people living in the informal settlements then we provide basic infrastructure that suit their livelihood and the nature of informal businesses that is taken place in there. You know we are doing that in order to keep people close to the CBD where they work. ……"*

7.3.3.5 Technology and Innovation

The interviewee was asked about the strategy employed by government to achieve sustainable construction in the affordable housing that has been delivered.

> *"…… we build with brick and mortar and other SANS approved building materials. Though there are some alternative building materials in use but not in large scale, when these alternative building materials are used its strictly based on request of the community or individuals. …. There is a lot of resistance from the people towards alternative building methods, the people want brick and mortar that's what they want in most instances our people believe you putting them into a modern-shacks when you build for them with materials other than brick and mortar"*

The respondent was asked on the waste reduction strategy employed in affordable housing construction to reduce material wastage. The respondent stated that the department only finances, it's the responsibility of contractors to manage waste in order to maximise profit.

On the specific method of construction, the respondent described the method of construction as the "Traditional construction" approach.

> *"in RSA, all the people want brick and mortar and there is lots of resistance towards alternative building methods, honestly, in RSA our people do not want alternative materials".*

7.3.4 CASE STUDY 4

7.3.4.1 Background information of Organisation D

Organisation 'D' was established in 1987 as a Housing and Property Development company to develop towns and suburbs in the Eastern Cape at the inception and later expanded its operations to the Kwazulu-Natal and Free State provinces of South Africa. The company core operation is residential housing development, it was established as a private property development company and it is one of the leading private property development companies that has entered into partnership with RSA government in affordable housing construction. The company ownership is 50% black and 50% white. The company has a cidb grading of 8GB (General Building) and registered with NHBRC. The company is currently on BBBEE Level 2.

7.3.4.2 Environmental sustainability consideration

As the quest to establish how environmental sustainability considerations influence decision making on housing projects continue, the interviewee, who is the CEO of organisation 'D', stated that the company has a policy framework for evaluation of the company projects' environmental sustainability. The respondent posited that building material selection is based on life-cycle assessment reports on the materials under consideration, though an independent organisation is usually engaged to conduct the evaluation for the company. Questions were posed about the influence of the company practices on the acceptability of the houses built by the company.

> *"….. our company design decision is largely influenced by the type of building materials we intend to use in conformity with government specification and the life-cycle assessment report on the materials. We engaged with the community in all our projects and the people are always happy with our project".*

The interviewee also contends that the company approach to affordable housing is "push to user approach" and not "user-pull approach". That is, the houses are built based on government decision in most cases.

> *"Government put subsidy and you must build within the subsidy and the new code is a bit better now government has increased the subsidy and people are getting better products now. The houses have been increased to 42m^2, government have introduced ceiling, plaster, paint, and more electricity".*

7.3.4.3 Housing Finance

The CEO of organisation 'D' describes the financing scheme used by the company to finance its private housing project as largely mortgage finance, and government housings were built through "Housing Subsidies". The respondent stressed that it is cheaper to build government houses through subsidies, even though the system is not sustainable in the long-run. The respondent also expressed worries over illegal sales of the government affordable housing below the prevailing market price. The respondent stated that:

> *"…. My opinion to government is that the housing subsidy should be abolished because the system is being abused by the people and considering the country's economic realities and unemployment rate. I think some other financing scheme that will make it mandatory for beneficiary of this house to contribute to the cost of construction must be employed by government".*

The respondent thus affirms the need to employ other means through which affordable housing could be financed to encourage construction of houses that are user-demanded and to put an end to illegal transfer/sales of houses at ridiculous prices.

7.3.4.4 Social-economic sustainability

Socio-economic analysis of a housing project is significant in determining whether community engagement, assessment of available infrastructure at the project site, assessment of building operation cost, introducing features to suit the traditional/spiritual need of the target user, consideration of the average household size in housing design, provision of facilities that encourage social activities and human interactions in the community, and engaging the labour within the community, among other social–economic factors, influence achievement of the project objectives. The respondent asserts that company placed greater importance to users' comfort through provision of basic infrastructure, community engagement and empowerment, and delivery of better quality housing.

> *"I think we are delivering a better house, we put schools, sport fields, parking arears, community hall, etc. and our goal is to develop townships to look nice. The problem in most of the housing built by other company is that they allow too much space to the front and leaving no space at the back of the building for expansion. This encourages building of shacks in the front by the beneficiary in attempt to create more space for his family".*

> *"…… we are worried about our towns, we build most of the suburbs in East-London, Durban and Bloemfontein, and we make sure that some of the people in the community were trained to partake in the construction so that they can have the required skills to do maintenance and repairs on the building when there is need for it, above all we are committed to leaving behind a well capacitated workforce that can work independently".*

It became obvious that sustainable affordable housing cannot be achieved in an environment where there is infrastructural deficit and where the local community was not engaged both at the planning and construction stage of the project.

7.3.4.5 Technology and Innovation

To establish the strategy employed by the company to achieve sustainable construction in the affordable housing constructed by the company, the respondent explained that his company has been employing some innovative technology in the houses constructed by the company.

> *"…….. the unique thing in our product is that, we use new building technology, the foundation is standard Raft with 100mm slabs, the external walls are constructed with lightweight blocks and its 4-hours Rated sound insulation and 37 SA hours value for thermal of 0.52 which is the same as Clay Brick, the materials used to mould the block doesn't absorb water so no water rising through the wall".*

The respondent was asked on the waste reduction strategy employed by the company to reduce material wastage:

> *"the block that we use is specially molded, so the wastage is less than 5% instead of 10% on a normal block/brick, we use cement and bedding powder instead of mortar for bedding, the system laid the block faster and reduces "wastages" because there are no people carrying mortar around during the construction".*

The respondent was also confronted with questions on measures to ensure affordability of the houses:

> *"We build energy efficiency into the houses that we build, we use solar it is very durable and is one-off thing, but gas you have to pay every month for gas. And we use good geyser with solar, you get warm water even when there is no sun for two days and provide basic infrastructure like water, electricity, sewers, etc."*

The respondent asserted that it is cheaper to build a unit of the housing considering the construction method and building materials used by the company for its projects, faster delivery rate and better quality is achieved.

On the specific method of construction, the respondent described the method of construction as "Fast Tracking construction method" though some aspects of the process are done using the traditional construction approach.

7.4 Summary of Findings

In addition to the case-by-case analysis of qualitative data reported in section 7.3, it is imperative to bring together various findings from individual case studies to draw an insight into the nature of relationships among the research constructs and the results from the empirical findings in Chapter 6.

The findings from the cases studied indicate the following;

- Housing financing system: The respondents affirm the need to employ other means through which affordable housing could be financed, so as to encourage construction of houses based on individual user-demand and to discourage illegal sale of the house below its market worth. It is also revealed that the use of other housing financing systems must be adopted to enable the housing beneficiary to take control of the process, since the system will necessitate monetary contribution from the beneficiaries. This will make the housing constructed through this arrangement sustainable as it will discourage illegal sale and continual emergence of shacks.
- Technology and innovation in construction: The result of analysis shows a consensus of opinion that it is expensive to build a unit of the housing, considering the construction method and building materials used for the project, while the delivery rate is faster and better quality housing is achieved, which in the long-run will nullify the

additional cost incurred during construction. Therefore, housing that will meet the needs of the present and still satisfy the needs of the future are built.

- Socio-economic sustainability: The findings have shown that the strength of achieving sustainable housing lies in: availability of basic infrastructure, engaging with the local community and encouraging capacity building through the project.

7.5 Chapter Summary

This chapter presents the results of case-by-case analysis of qualitative interviews conducted with four research participants. The identities of the respondents were masked in order to fulfil the ethical requirements of conducting research of this nature; hence, the respondents were identified with letters of the alphabet, such as “organisation A” and so on. It is worthy to state that these participants were part of the professionals that took part in the quantitative survey and indicated willingness to be interviewed. However, the findings have validated the significance of sustainable financing methods, technology and innovation in construction and engaging the stakeholders at all levels of the housing construction process, to enhance sustainability in affordable housing. Hence, there is a need to include these constructs in the structural model developed in the subsequent chapter of this thesis.

CHAPTER EIGHT
DEVELOPING STRUCTURAL MODEL FOR SUSTAINABILITY ENHANCEMENT IN HOUSING CONSTRUCTION

8.1 INTRODUCTION

In the previous chapter, data was analysed using descriptive statistics, Principal Component Analysis (PCA) and Cross-case analysis. The results of analysis in chapters six and seven have established latent factors contributing to individual constructs in the study conceptual framework presented in Chapter 3 of this thesis.

Thus, this chapter presents the development of a structural model for enhancing sustainability in housing construction using the "Structural Equation Model" technique (SEM). The SEM involves two stage analysis namely; measurement model and the assessment of structural model. Measurement model, which is the first stage in SEM, involves assessing the links between the latent and manifest variables, while the assessment of the structural model specifies the links between the latent factors. To rap-up the model development, calculation of the path coefficients, which are the indicators of the predictive strength of the model, was estimated and analysed to test the structural model.

8.2 STRUCTURAL EQUATION MODEL

Justification for choosing SEM as the technique for developing the sustainability enhancement model for housing construction has been discussed in Chapter 5; section 5.5.7 of this thesis. Authors (notably Fernandes, 2012; Hair, Sarstedt, Pieper & Ringle, 2012) have described SEM as a second-generation multivariate analysis approach that brings together attributes of the first generation methods, such as PCA and linear regression analysis. This uniqueness of SEM permits researchers to test complete theories, concepts and complex models by estimating the composite relationship between the variables (Gil-Garcia, 2008; Robins, 2012).

The SEM technique for modelling can be covariance-based SEM (CB-SEM) or variance-based partial least square SEM (PLS-SEM). According to Henseler, *et al.,* (2014) CB-SEM is a confirmatory technique that focuses on the model parameters theoretically to estimate the relationships and aims at reducing the discrepancies between sample covariance matrix. While, PLS-SEM is a predictive approach, which aims at expanding the explained variance by focusing on the endogenous target construct in the model, such as R^2 value (Hair, *et al*., 2012; Henseler, *et al*., 2014).

It is however important to state that many studies on sustainability and housing have used different statistical techniques, such as linear and multiple regressions, for model development. This study thus employs PLS-SEM, which is a multivariate technique that enables an exploration set of relationships between one or more outcome variables, either continuous or separate. Moreover, PLS-SEM technique is utilised because it has been argued to be a superior technique for refining and developing theoretical models, which is the focus of this study (Robsin, 2012; Hair, *et al*., 2012; Henseler, *et al*., 2014).

8.3 MODEL FITTING AND ANALYSIS USING PLS-SEM

According to Elbanna, *et al.*, (2013) PLS-SEM is considered to be the most appropriate method for the development of new theory. However, to achieve strong PLS-SEM, basic assumptions that *"the sample size must be a minimum of ten times the number of path relationships leading to endogenous construct"* were satisfied to establish sample size (Elbanna, *et al.,* 2013). In addition to this assumption, there are four main paths leading to sustainability enhancement in affordable housing construction, therefore, a minimum sample size of 40 observations could be used. The main goal of developing this model was to establish the links, nature of relationship and the relative predictive power of the variables among the latent constructs.

8.3.1 Selection of Variables for Sustainable Affordable Housing Construction Model

Variables for the model development were selected after critical analysis of data conducted in chapters six and seven of this thesis. These variables were the variables that contributed most significantly to their individual construct.

As presented in Table 8.1, eight measurement variables contributed to user satisfaction latent construct. On the housing finance construct, four housing finance concepts were selected from five concepts investigated in this study, all five measurement variables were selected based on the significance of the variable's contribution to the selection of an appropriate financing system that enhances sustainability in construction of housing. Latent variable for construction methods comprises of traditional, concurrent engineering, modular and lean construction methods. Under each of these, four measurement variables were selected to be included in the housing construction sustainability enhancement model. On the social sustainability construct, the four most ranked factors under the social indicators at inception, design and construction stages of housing construction, were the measurement variables selected.

Table 8. 1 Conceptual model latent variables

Latent variable constructs	Measurement variable	
Satisfaction variables (HSF)	Energy saving electrical appliance	HSF8
	Water saving sanitary appliances	HSF11
	Household size	HSF6
	Lack of information on sustainable materials	HSF5
	Budget constraint	HSF1
	Cost of eco-friendly building materials	HSF2
Housing finance concepts	Commitment to deliver quality housing	HFSV1
Down Payment Grant (HFDPG)	Enhance delivery of affordable housing	HFSV2
Mortgage Payment Subsidies (HFMPS)	Encourage user participation	HFSV3
Mortgage Interest deduction (HFMD)	Reduction in payment default	HFSV4
Credit Enhancement (HFCE)	Enhance provision of free housing	HFSV5
Construction Methods		
Traditional construction method (TCM)	Minimise cost of construction	TCM6
	Minimise material wastages	TCM2
	Simplicity of construction	TCM1
Concurrent engineering (CEM)	Eliminate material wastage	CEM2
	Minimise cost of construction	CEM7
	Enhanced construction speed	CEM3
	Increase quality	CEM5
Modular construction method (MCM)	Reduce construction time	MCM9
	Avoid material wastage	MCM2
	Minimise cost of construction	MCM6
	Reduce use of non-renewable materials	MCM3
Lean concept	Avoid material wastage	LCC2
	Minimise negative impact on environment	LCC1
	Minimise cost of construction	LCC6
	Improve quality	LCC3
Social sustainability factors (SSF)		
Social indicator at Inception stage (SSI)	Health and safety	SSI5
	Infrastructure development	SSI6
	Household size	SSI4
	Stakeholders engagement	SSI1
Social indicator at Design stage (SSD)	Stakeholders engagement	SSD1
	Communal interaction	SSD4
	Building operating cost	SSD6
	Protection of natural habitat	SSD7
Social indicator at construction stage (SSC)	Use of local resources	SSC2
	Employment opportunity	SSC1
	Community participation	SSC5
	Health and safety during construction	SSC7

In addition to selection of latent variables contained in Table 8.1, these variables were regrouped based on the frequency of occurrence of each variable under each element that make up the constructs. This therefore led to the emergence of Table 8.2, which contains the list of re-grouped variables that were inputted into the PLS-SEM for model development.

Table 8. 2 Conceptual model latent variables extracted

Latent variable constructs	Measurement variable	
Satisfaction variables (HSF)	Energy saving electrical appliance	HSF8
	Water saving sanitary appliances	HSF11
	Household size	HSF6
	Lack of information on sustainable materials	HSF5
	Budget constraint	HSF1
	Cost of eco-friendly building materials	HSF2
Housing finance concepts	Commitment to deliver quality housing	HFSV1
Down Payment Grant (HFDPG)	Enhance delivery of affordable housing	HFSV2
Mortgage Payment Subsidies (HFMPS)	Encourage user participation	HFSV3
Mortgage Interest deduction (HFMD)	Reduction in payment default	HFSV4
Credit Enhancement (HFCE)	Enhance provision of free housing	HFSV5
Construction Methods		
Traditional construction method (TCM)	Simplicity of construction	CMF1
Concurrent engineering (CEM)	Eliminate material wastage	CMF2
Modular construction method (MCM)	Reduce use of non-renewable materials	CMF3
Lean concept	Improve quality	CMF4
	Minimise cost of construction	CMF5
	Minimise negative impact on environment	CMF6
Social sustainability factors (SSF)		
Social indicator at Inception stage (SSI)	Health and safety	SSI5
Social indicator at Design stage (SSD)	Infrastructure development	SSI6
Social indicator at construction stage (SSC)	Household size	SSI4
	Stakeholders engagement	SSD1
	Communal interaction	SSD4
	Building operating cost	SSD6
	Protection of natural habitat	SSD7
	Use of local resources	SSC2
	Employment opportunity	SSC1
	Health and safety during construction	SSC7

8.3.2 Measurement Model Results

The Measurement model for this study was developed using SmartPLS (version 2.0M3) Software to access the measurement capacities of the explanatory variables and the predictive strength of the model. To obtain the measurement model results, all the possible structural relationships among the constructs were drawn and the reflective indicator of the constructs turned from red to blue, which indicates that all the constructs have some degree of relationship with each other.

Having established that the constructs have some relationship, the PLS algorithm was then used to calculate the standardised regression rate, factor loadings and the percentage variance (R^2 value) explained by the explanatory variables. After the first iteration of the latent variable, variable items with small factor loading (<0.5) were removed since their contribution to the model is insignificant. This decision was in conformity with the position of Chu, Hsiao, Lee and Chen (2004); and Fornell and Larcker (1981), that variables with factor loadings of 0.7 and above (≥ 0.7) be retained. Though, this study considers 0.5 as the threshold for factor loading, since 0.5 was used in the PCA analysis reported in previous chapters of this thesis.

Going forward, individual item reliability was examined on the latent constructs. Reliability results are given in Table 8.3. The result indicates that the measures are robust in terms of their internal consistency reliability as shown by the composite reliability. The composite reliabilities of the different measures range from approximately 0.78 to 0.88, which exceed the recommended threshold value of 0.70 by (Nunnally, 1978 cited in Al-Gahtani, Hubona & Wang, 2007). The higher the factor loading, the more variance is shared between the latent variables and its indicators. Convergent validity was assessed using the Average Variance Extracted (AVE) for each of the constructs, to evaluate the agreement between two or more variables of the constructs. According to Fornell and Lacker (1981), when AVE is less than 0.50, the variance due to measurement error is larger than the variance captured by the construct. Though the author (Fornell, & Lacker, 1981) further contends that based on “composite reliability” alone, convergent validity of the construct may be concluded to be adequate. In the same vein, Henseler, *et al.,* (2014) opine that if the AVE is higher than 0.5, convergence is established. The results displayed in Table 8.3 showed that all the constructs converged, judging from both the AVE and Composite Reliability (CR) results, above 0.5 and 0.7 thresholds for AVE and CR respectively.

The elements in the matrix diagonals, representing the square roots of the AVEs, are in all cases greater than the off-diagonal elements in their corresponding row and column, supporting the discriminant validity of the scales used. However, the results indicate higher factor loadings and the constructs indicated adequate shared variance with their indicators. Therefore, the model has acceptable reliability and validity in explaining and predicting the links among the constructs in the model.

Table 8. 3 Latent variables inter construct correlation and reliability measure

	AVE (Average variance extracted	Composite Reliability	R Square	Cronbach's Alpha	Const methd	HSF	Hfinance	POB	SSF
Const methd	0.5380	0.7771	0.3559	0.5734	1				
HSF	0.6396	0.8412	0.1478	0.7358	0.0881	1			
Hfinance	0.5435	0.8545		0.7846	0.1351	0.3786	1		
POB	0.6538	0.8826	0.4276	0.8223	0.5898	0.0836	0.1448	1	
SSF	0.5194	0.8111		0.6896	0.5923	0.0184	0.1090	0.5714	1

8.3.3 Validation of Structural Model Results

The convergent validity was tested by linking together the endogenous latent constructs in the model through SmartPLS-Graph, to extract the factor and cross loadings of all indicator items to their respective latent constructs. The measurement model results, presented in Table 8.4, indicated that all items loaded on their respective construct from a lower bound of 0.60 to an upper bound of 0.85; and more highly on their respective construct. The constructs' items' loadings and cross loadings presented in Table 8.4 for each individual item loading confirm the convergent validity of these indicators as representing distinct latent constructs which is highly significant to the achievement of the study goal of developing a model to enhance sustainability in housing construction.

In the proposed structural model presented in Figure 8.1 interaction effects were examined by running the PLS-algorithm to identify the relationship (if any) existing among the constructs. The reason for running the PLS-algorithm is to identify the variance explained by the variables included in the model and to establish the significance level of all paths leading to the PLS estimate. The path coefficient was also assessed and the results presented in Table 8.5. The path coefficient shows the contribution of each latent explanatory construct to the predictive ability of the endogenous construct. The coefficient shows that the endogenous constructs have positive contributions towards each other with exception of SSF who has negative contribution to HSF.

Chin (2010) asserts that the predictive ability of a structural model is evaluated by the R^2 value of the endogenous constructs in the model. Hence, the R^2 value was calculated and the results show that the R^2 values of the endogenous constructs are above 10% which is acceptable (Fornell & Lacker, 1981; Henseler, *et al.,* 2014).

Table 8. 4 Factor loadings (bolded) and cross loadings for measurement model

	Const methd	HSF	Hfinance	POB	SSF
CMF1	**0.7040**	0.0697	0.0119	0.4261	0.3504
CMF2	**0.7185**	0.0433	0.1129	0.4257	0.4022
CMF5	**0.7760**	0.0792	0.1565	0.4476	0.5312
HFSV1	-0.0057	0.3175	**0.7869**	0.1066	-0.0458
HFSV2	0.1538	0.2707	**0.8218**	0.0363	0.1029
HFSV3	0.2340	0.2499	**0.7947**	0.1713	0.1587
HFSV4	0.0142	0.2563	**0.6455**	0.0960	0.0903
HFSV6	0.0734	0.2965	**0.6123**	0.1094	0.0878
HSF11	0.0564	**0.8155**	0.2897	0.0202	-0.0125
HSF6	0.1145	**0.8542**	0.3756	0.1181	0.0262
HSF8	0.0030	**0.7239**	0.1909	0.0352	0.0344
POB2	0.5513	0.1156	0.1923	**0.8824**	0.5421
POB3	0.4563	0.0009	0.0608	**0.7197**	0.4023
POB5	0.3931	0.0828	0.0820	**0.8096**	0.3872
POB6	0.4853	0.0602	0.1111	**0.8144**	0.4907
SSC1	0.4504	0.0235	0.1248	0.4370	**0.7945**
SSC2	0.4817	-0.0432	0.0663	0.4569	**0.7514**
SSC7	0.3624	0.0648	-0.0080	0.3934	**0.6837**
SSD1	0.4022	0.0199	0.1275	0.3510	**0.6437**

Table 8. 5 Path coefficient of the constructs

	Const methd	HSF	Hfinance	POB	SSF
Const methd		0.0781		0.3790	
HSF				0.0263	
Hfinance	0.0714	0.3756		0.0464	
POB					
SSF	0.5845	-0.0688		0.3414	

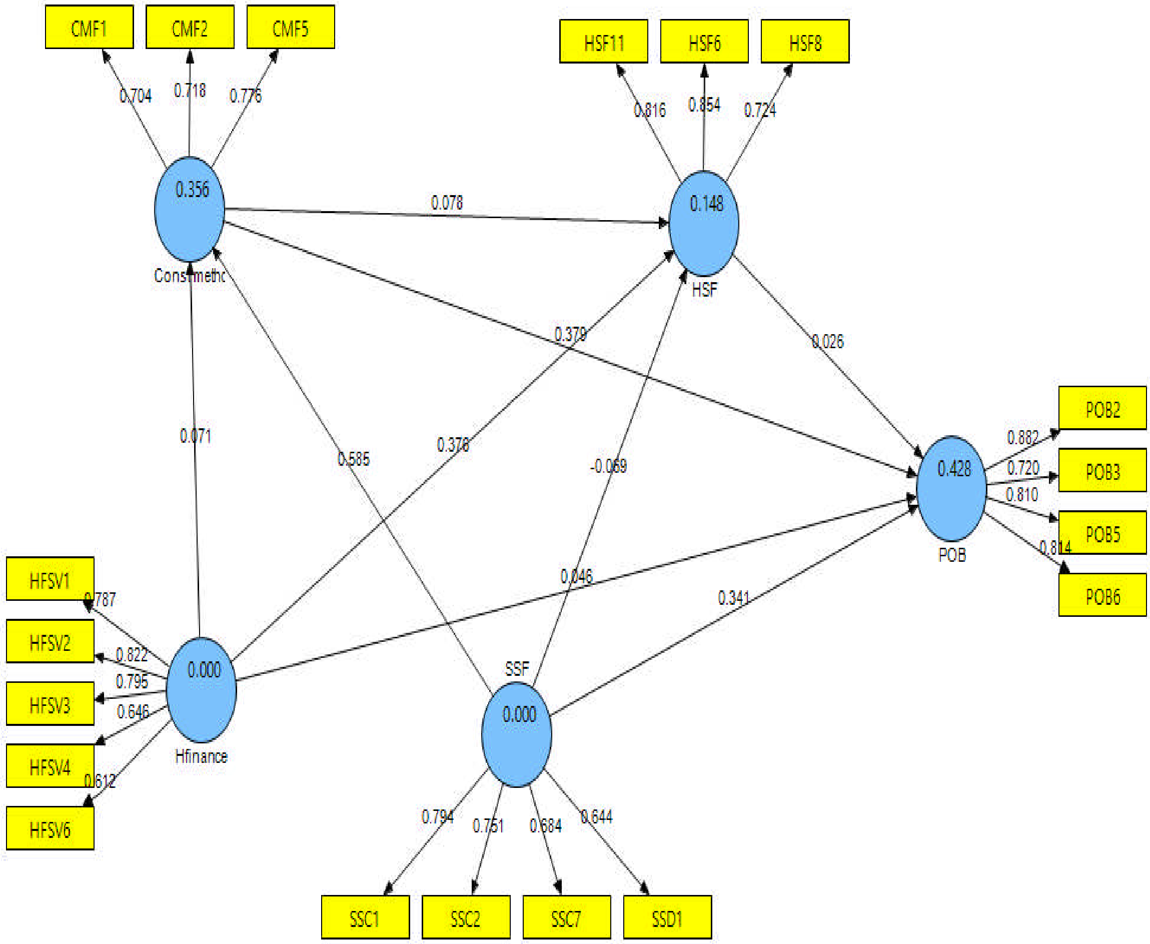

Figure 8. 1: Structural model with path coefficient and R-square values

To test for significance of PLS-SEM paths, SmartPLS utilises the "bootstrapping" technique to resample the cases in order to determine the significance level of the variables. Therefore, to determine the significance level of the variables in this study, bootstrapping was performed using 500 resamples. Table 8.6 presents the results of t-statistics and Figure 8.2 shows the structural model with the path coefficients and t-statistics. The underlying assumption is that if the resultant empirical t-value is above 1.96, it shows that the path coefficient is significant at 5% significance level; when the t-value is above 2.57, it is significance at 1% and when the t-value is above 1.65, it is significant at 10%. Furthermore, each item's factor loading on its respective construct was highly significant ($p < 0.001$) as indicated by the t-statistics of the outer model loadings.

Table 8. 6 PLS path modelling bootstrapping results with t-statistics

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
CMF1 <- Const methd	0.4049	0.4058	0.1085	0.1085	3.7316
CMF2 <- Const methd	0.4354	0.3767	0.1432	0.1432	3.0414
CMF5 <- Const methd	0.5182	0.5524	0.1413	0.1413	3.6669
HFSV1 <- Hfinance	0.2757	0.2833	0.0848	0.0848	3.2513
HFSV2 <- Hfinance	0.2628	0.2619	0.0627	0.0627	4.1920
HFSV3 <- Hfinance	0.3088	0.2899	0.1039	0.1039	2.9731
HFSV4 <- Hfinance	0.2307	0.2288	0.0799	0.0799	2.8881
HFSV6 <- Hfinance	0.2821	0.2757	0.0916	0.0916	3.0802
HSF11 <- HSF	0.4107	0.4165	0.0742	0.0742	5.5343
HSF6 <- HSF	0.5607	0.5025	0.1138	0.1138	4.9287
HSF8 <- HSF	0.2571	0.3036	0.0989	0.0989	2.5999
POB2 <- POB	0.3665	0.3919	0.0811	0.0811	4.5184
POB3 <- POB	0.2827	0.2709	0.0778	0.0778	3.6342
POB5 <- POB	0.2592	0.2575	0.0743	0.0743	3.4871
POB6 <- POB	0.3233	0.3296	0.0537	0.0537	6.0264
SSC1 <- SSF	0.3680	0.3556	0.0974	0.0974	3.7789
SSC2 <- SSF	0.3884	0.3815	0.1067	0.1067	3.6407
SSC7 <- SSF	0.3138	0.3319	0.1063	0.1063	2.9514
SSD1 <- SSF	0.3127	0.3354	0.0982	0.0982	3.1827

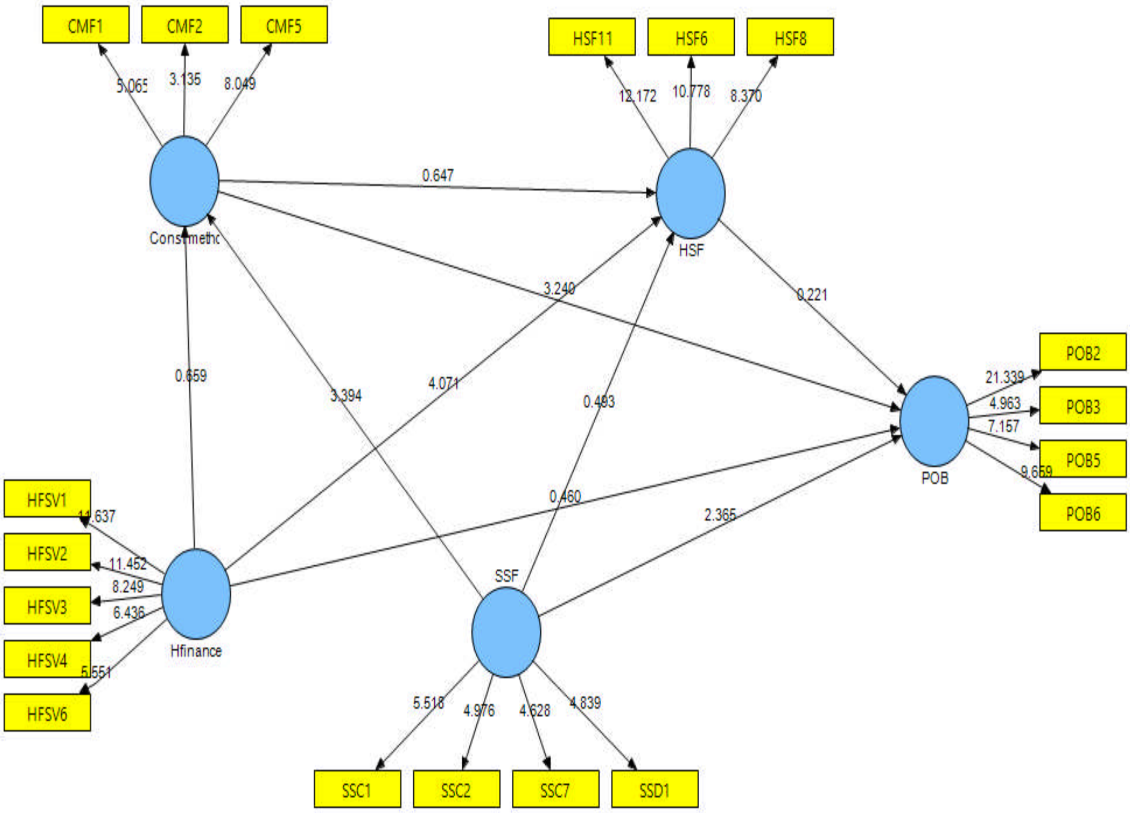

Figure 8. 2: Structural model with t-statistics values

8.3.4 Structural Equations to Validate the Structural Model

The structural model presented in Figure 8.1 and Figure 8.2 shows how the latent constructs link with each other. Latent variables are classified into two according to Monecke and Leisch (2012), and Sanchez (2013), as endogenous and exogenous variables. According to these authors, endogenous variables are variables that are produced by one or more of the variables included in the model. Endogenous variables have both incoming arrows and intervening causal variables. While exogenous variables are variables produced by variables external to the model and whose function is to offer explanations on variables within the model.

In the structural model (Figure 8.2 and 8.3), housing finance and social sustainability are the exogenous variables, as they do not have preceding variables in the model. Moreover, the PLS-SEM structural model is a combination of Linear Regressions, hence all the relationships in Figure 8.3 are considered to be linear, causal and additive (Hair, *et* *al*., 2012). The model in this study has three endogenous variables, and three sets of standardised coefficient were estimated from the PLS-SEM. These PLS-SEM path equations relate to the causal link hypothesised in this study. The ε represents the error terms which denotes that the variations remain unexplained by the predicting variables within the path model. The equations are:

- Housing finance = HFinace + 0(Exogenous variable) ……………………………...1
- Construction method selection = PAB (Housing finance) + PDB (social sustainability) + ε_1 ……………………………………………………………………………...2
- Social sustainability = SSfactors + 0(Exogenous variable) + ε_2 ……………………….. 3
- Housing satisfaction = PAC (housing finance) + PBC (construction method) + PDC (social sustainability) + ε_3 …………… 4
- Achieve project objectives = PAE (housing finance) + PBE (construction method) + PDE (social sustainability) + PCE (Housing satisfaction) + ε5 ………… 5

The abbreviations below represent the path coefficient shown in figure 8.3.

Housing Finance System -> Construction Methods ……………………….. PAB
Construction Methods -> Measure of Housing Satisfaction ………………. PBC
Housing Finance System -> Measure of Housing Satisfaction …………... PAC
Construction Methods -> Achieve sustainable housing ……………………. PBE
Housing Finance System -> Achieve sustainable housing ………………. PAE
Social sustainability -> Construction methods ……………………………….. PDB
Social sustainability -> Measure of Housing Satisfaction ………………….. PDC
Social sustainability -> Achieve sustainable housing ……………………… PDE
Measure of Housing Satisfaction -> Achieve sustainable housing ……… PCE

Figure 8.4 further shows the alignment between the achievement of project objectives, which is the ultimate goal of enhancing sustainability in affordable housing construction and the constructs. The measurement variables for each construct were also shown in this model.

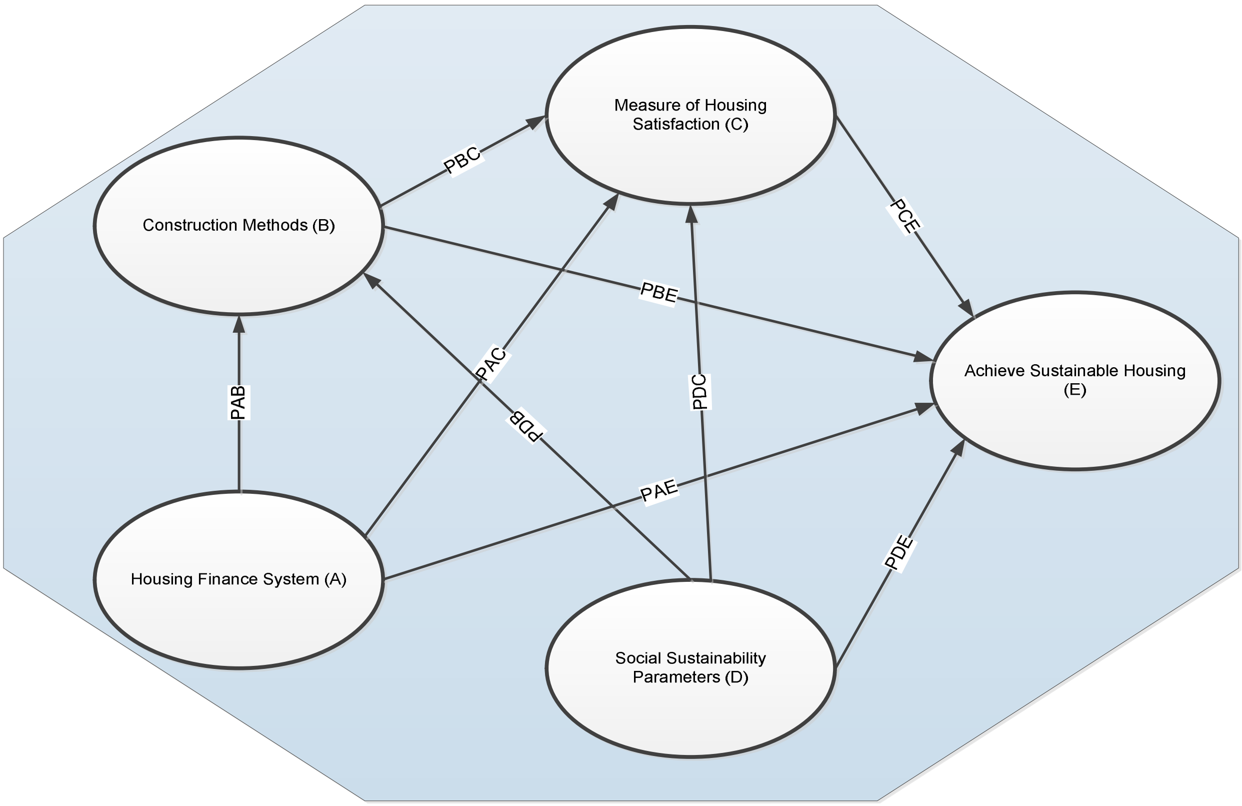

Figure 8. 3: Causality structural model explaining underlying factors to achieve sustainable construction

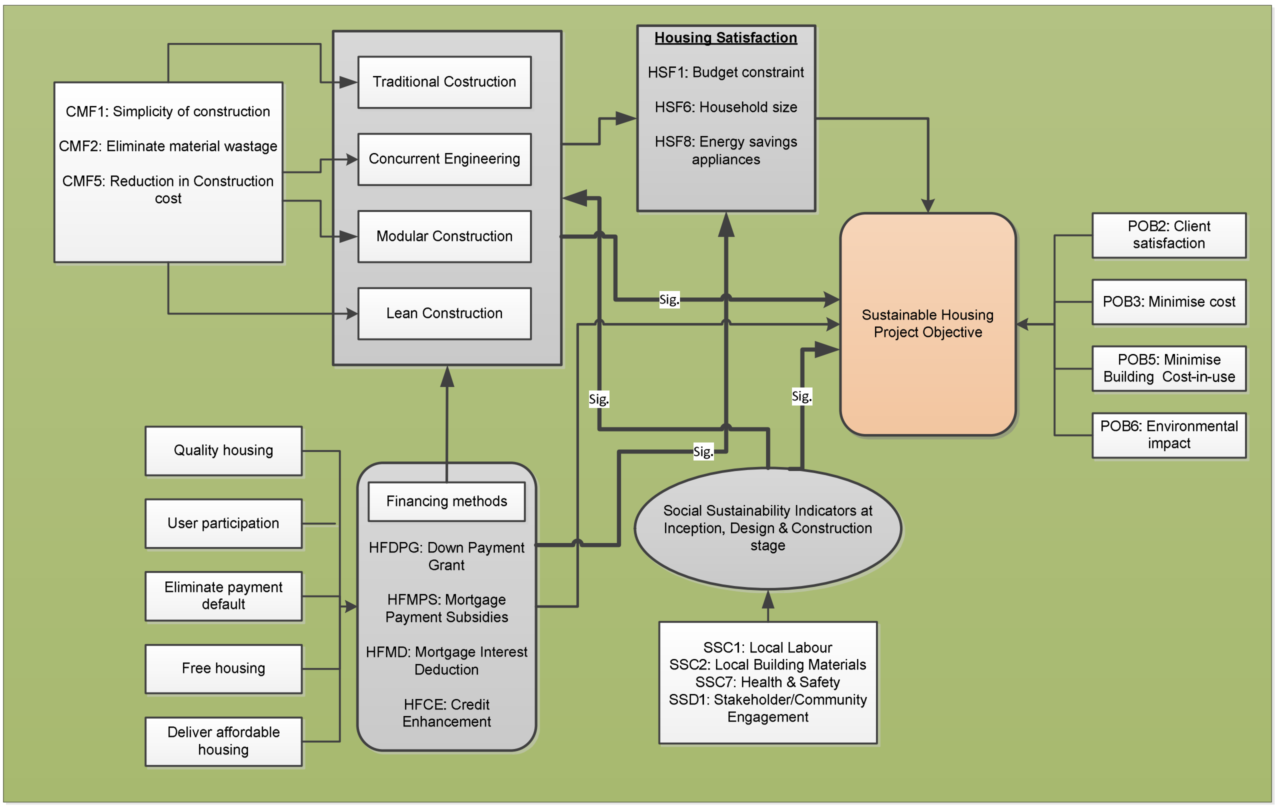

Figure 8. 4 Model for sustainable housing project objectives aligned with the constructs

8.3.5 Model Evaluation

To evaluate PLS path model, attention must be given to the R^2 value, which is the prediction strength, and non-parametric assessment criteria in addition to resampling techniques in evaluating the adequacy or fitness of PLS model structures (Chin, 2010). Therefore, R-square value was used in this study as the criterion used to predict the significance of the model. It is worthy to note that there is no overall fit index in PLS Path Modeling. Nevertheless, a global criterion of goodness of fit has been proposed by Tenenhaus et al. (2004) cited in Henseler and Sarstedt, (2013). The GoF index is such an index that has been developed in order to take into account the model performance in both the measurement and the structural model, and thus provides a single measure for the overall prediction performance of the model. For this reason the GoF index is obtained as the geometric mean of the *average communality* index and the average R^2 value, denoted mathematically as:

$$GoF = \sqrt{\emptyset com \times \emptyset R^2}$$

Where; Ɵcom is the average communality and ƟR^2 is the average inner R-square value

Therefore, using the GoF formula and the values in Table 8.3, the GoF value of 0.3577 was obtained for the entire model. The GoF value calculated thus falls within the threshold values of 0.25 and 0.36 for small and large sizes of R^2. Consequently, the study concludes that the PLS model developed in this study has significant explanatory power and offers average support to validate the PLS model globally.

8.4 DISCUSSION OF FINDINGS FROM THE MODEL RESULTS

The results from the structural model developed in this study have shown that a housing financing system deployed for a housing project and given due cognisance to social sustainability factors has a predictive power of 35.6% (R^2 value: 0.356) to influence the choice of construction method for a housing project. The relationships were significant and are positively related, which implies that sustainability of housing can be achieved in a housing project right from the construction stage of the project. Housing finance explained 7.1% contribution to construction method and social sustainability explained 58.5% contribution to construction. Taking cognisance of indicators; commitment to deliver high quality, delivery of affordable housing, prospective home owner participation and reduction in payment default that contribute to the financing system, will ensure better decisions in choosing an appropriate mode of finance for housing as summarised by the model (path coefficient (r) = 0.071; t = 0.659). Similarly on the social sustainability side; engaging local community at the design stage, employment of construction workers within the local community, use of local building materials, and health and safety during construction are the reflective indicators that contribute to the significance of social sustainability to the selection of construction methods as summarised by the model (path (r) = 0.585; t = 3.394).

The model results also showed that housing finance system, social sustainability and construction methods have strong relationships with measure of housing satisfaction. Although, the relationship exhibited by social sustainability with housing satisfaction is negative (path (r) = - 0.069; t = 0.483), while housing finance and construction method have positive relationships. The significance level of relationship exhibited by housing finance system is summarised by the model (path (r) = 0.378; t = 4.071) and construction method is summarised as (path (r) = 0.078; t = 0.647). However, the reflective indicators; simplifying the construction process combined with eliminating materials wastages, will ensure reduction in cost of construction, thereby delivering acceptable and affordable sustainable housing to the home owner at optimum satisfaction to the house owner. Therefore, combining these construction method indicators with housing finance and social sustainability indicators resulted in predictive strength with an R^2 value of 14.8%, which is above the 10% acceptable R^2 value suggested by Henseler, *et al.,* (2014). It implies that the resultant effect of the combined strength of these indicators will lead to producing houses on the basis of individual household size and could adopt the use of water and energy saving appliances, which in turn reduces the negative impact of building on the environment as well as reducing the building running cost.

Going forward, the model examines the relationships that exist between housing finance system, construction method selection, social sustainability indicators and measure of housing satisfaction to house owner, and the expected objectives of the housing project. However, the model indicates that housing finance has predictive strength of 4.6% to influence achievement of project goals of satisfying building owner specification, minimising cost of construction, minimising building cost-in-use, and minimising building impact on the environment, however the relationship is positive but insignificant (path (r) = 0.046; t = 0.460). The model also revealed that appropriate construction method selection has predictive strength of 37.9% to influence achievement of the aforementioned project goals. Construction method has a positive significant relationship with achievement of project objectives as summarised by the model (path (r) = 0.379; t = 3.240). The results on the housing satisfaction indicator's predictive strength in achieving project goals showed that it has 2.6% contribution, a with positive but insignificant relationship (path (r)

= 0.026; t = 0.221). Lastly, the model showed that social sustainability indicators have a very strong significant and positive relationship with achievement of project goals. The predictive strength of social sustainability indicator is 34.1% and significant at 5% level of significance as summarised by the model (path (r) = 0.341; t = 2.365).

Summarily, the results of the structural model have showed that construction method selection and social sustainability indicators have strong relationships and high predictive capabilities to influence achievement of project objectives of constructing houses that are sustainable as well as affordable to the poor population. Housing financing system and measure of user satisfaction indicators have weak predictive powers and insignificant relationships, but both have exhibited positive relationships. However, the overall predictive strength of all the constructs to realising construction of sustainable affordable housing is strong with R^2 value of 42.8%. This strong predictive strength has upheld the research proposition that a combination of the four constructs (construction method, mode of financing, construction social sustainability indicator and user satisfaction indicator) could lead to construction of sustainable affordable housing. Therefore, Table 8.7 provides the summary of the research outcomes on the hypotheses.

APPLICATION OF THE PLS MODEL

SmartPLS is a SEM which is a very useful and robust technique for both empirical and theoretical research, and its applications in construction research has continued to increase (Xiong, Skitmore & Xia, 2015). Partial least squares (PLS) was used for constructing models for predictive purposes. This is employed in this research as a result of the availability of many factors capable of influencing the achievement of sustainability in construction of affordable housing. PLS-SEM offers some systemic basis for predicting and evaluating the performance of a model. PLS regression as a tool can handle a very large number of predictors and can thus be applied to model a problem without adaptation, as it manages to account for the complexity between the factors mentioned in the model (Boulesteix & Strimmer, 2006; Fischer, 2012). Therefore, this presents a practical application of PLS-SEM to the conceptual model presented in Chapter 3 of the thesis for evaluating relationships between the established constructs in this study.

Table 8. 7 Summary of the effects of structural model results on hypothesised links in PLS-SEM path model

Path label	Path relationship	T-statistics	Corresponding hypothesised path	Remark on hypothesis
PBE	Construction Methods -> Achieve sustainable housing	Significant	*Hypothesis$_{1a}$*: Choice of appropriate construction method is significant to realising sustainability in affordable housing	strongly supported
PBC	Construction Methods -> Measure of Housing Satisfaction	Not significant	*Hypothesis$_{1b}$*: There is relationship between construction method chosen for construction and achievement of user requirements	supported
PAB	Housing Finance System -> Construction Methods	Not significant	*Hypothesis$_{2a}$*: Housing finance will influence the choice of construction method	supported
PAC	Housing Finance System -> Measure of Housing Satisfaction	Significant	*Hypothesis$_{2b}$*: Housing financing system adopted for a project have relationship with the level of user satisfaction on the houses produced	strongly supported
PAE	Housing Finance System -> Achieve sustainable housing	Not significant	*Hypothesis$_{2c}$*: There is significant relationship between housing finance system and achievement of project objectives	supported
PDB	Social sustainability -> Construction methods	Significant	*Hypothesis$_{3a}$*: There is relationship between social sustainability indicator choice of construction method	strongly supported
PDC	Social sustainability -> Measure of Housing Satisfaction	Not significant	*Hypothesis$_{3b}$*: There is relationship between social sustainability and level of user satisfaction on the houses produced	Not supported
PDE	Social sustainability -> Achieve sustainable housing	Significant	*Hypothesis$_{3c}$*: The social sustainability indicators will exhibit relationship with achievement of sustainable housing construction	strongly supported
PCE	Measure of housing satisfaction -> Achieve sustainable housing	Not significant	*Hypothesis$_{4}$*: There is relationship between level of user satisfaction and achievement of project objectives	supported
	Combined paths	Significant	*Hypothesis$_{5}$*: When construction method, mode of financing, construction social sustainability indicator and user satisfaction indicator are combined, construction of sustainable affordable housing is achievable	strongly supported

8.5 Summary of Chapter Eight

PLS-SEM was used in this study to test the conceptual model formulated in Chapter 4 of this thesis, by examining the nature of relationships that exist between the constructs within the model. The structural model showed that a positive relationship exists between most of the causal links while one of the links exhibited a negative relationship. The results represent high predictive (explanatory) power of the model based on the R^2 value of approximately 43% exhibited by all explanatory constructs in the model. The GoF (goodness of fit) values were also determined for model fitting and for validation, and the results showed that the model can predict the sustainability in the construction process of housing projects and is adequate for worldwide validation for partial least square model path.

CHAPTER NINE
SUMMARY OF RESEARCH FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

9.1 INTRODUCTION

This chapter presents a recap of the study. It embraces findings from the extant literature on construction management, sustainable construction and sustainability. The literature review assisted in providing a wider view and better understanding of sustainable construction and housing concepts involved in the study, which led to the development of the research instrument and the sustainable affordable construction model. The findings from this study are linked to the conclusion and presented in this chapter. The recommendations provide suggestion for future research, which emerged because of the findings from this study. The study's contribution to the body of knowledge and limitations are highlighted in this chapter.

9.2 REVIEW OF AIM AND OBJECTIVES

The principal aim of this study is to provide an answer to this main research question *"How could sustainability be introduced in the construction of affordable housing through the knowledge of housing financing, socio-economic aspects of sustainability, and construction methods to enhance sustainability in housing delivery?"*

To provide answers to the issues surrounding the question, the study identified the following specific objectives:

- To identify and ascertain user requirements in sustainable affordable housing.
- To identify and establish the effective housing finance mechanism to achieve construction of affordable housing and enhance sustainability.
- Evaluate and identify the key factors that affect the construction cost of sustainable housing.
- To identify and establish construction concepts that could be used to produce affordable housing that is sustainable.
- To develop and validate an operational model for implementing affordable housing construction to enhance sustainability.

In order to achieve these objectives, the study conducted an extensive review of extant literature to have an understanding of the past efforts on the subject of the research and to identify measures for the research constructs. This thesis critically examines the environmental problem associated with construction activities and investigates ways of implementing sustainable practice in the planning and construction of housing, using the most appropriate financing system and construction method. In acknowledging the importance of considering sustainability issues in affordable housing construction, the socio-economic indicators influencing affordable housing development was critically examined and discussed. This was explored by identifying and measuring the principal sustainable development criteria that enhance socio-economic considerations within a sustainable assessment framework for building construction.

In addressing the objectives of this study, a systematic approach to data collection and analysis was employed. The study adopted a sequential mixed method approach to obtain both quantitative and qualitative data using survey questionnaire and case study (interview) to gather empirical data. Therefore, the findings emanating from the methodical approaches used in achieving the study objectives is summarised in the subsequent section of this chapter.

9.2.1 User Requirements in Sustainable Affordable Housing

The first specific objective of the research investigates user requirements in sustainable housing. The literature review in chapters two and three discovered that housing provision has an inherent connection with economic growth of the people. The growth of a nation's economy is largely dependent on the availability of shelter to its citizens, who are the drivers of the economic activities. Literature revealed that healthy, safe, secure and affordable housing within a healthy neighbourhood environment with provision of basic infrastructure is desirable to grow the economy. It was also discovered from literature that building owners and users desire appliances that reduce energy consumption in their homes, which in turn leads to reduction in building cost-in-use.

Moreover, thirteen variables were identified from literatures and the findings from the analysis discussed in Chapter 6 (section 6.4.2 to 6.4.2.2.1) show that user satisfaction in housing is enhanced through:

- use of energy saving appliances
- use of water saving sanitary appliances
- considering user household size at planning stage of housing

- use of eco-friendly building materials
- lack of finance was identified as constraint.

The user requirement factors established were incorporated into the sustainable affordable housing construction model developed in this study and presented in Chapter 8.

9.2.2 Housing Financing Mechanism

The second objective of the study is to identify housing financing mechanisms through literature and establish the effectiveness of these financing mechanisms in the delivery of sustainable affordable housing. Five housing finance systems were found appropriate for use to finance housing projects from literature. The unique characteristics of these financing systems were put together as variables for measuring the effectiveness of each concept. The results showed that down payment grant, mortgage payment subsidies, mortgage interest deduction and credit enhancement are the most effective systems to finance construction of affordable housing to enhance sustainability. The results showed further that the financing concepts will enhance:

- Delivery of affordable housing
- Commitment of the developer to deliver high quality housing
- User participation
- Reduce payment default
- Encourage contribution from home buyer

However, the effective housing financing concept established for housing project finance was a construct in the sustainable construction model developed in Chapter 8, and was found to have a significant relationship and positive contribution to the realisation of sustainable housing construction. The results of analysis on housing financing systems in this thesis have demonstrated that sustainable affordable housing construction will best be achieved through a combination of two or more financing concepts, since the economic situation of individual house owners differs from one another.

9.2.3 Identifying Factors that Affect the Construction Cost of Sustainable Housing

The third objective of this study was to evaluate and identify the key factors that affect the construction cost of sustainable housing. The study identified both the economic, social, environmental and human variables that influence cost of construction directly or indirectly from literature. The literatures suggest that careful evaluation of the variable is crucial to achieving sustainable construction. The study adopts both the descriptive statistical technique and Principal Component Analysis (PCA) to evaluate the variables identified from literature. From the results of analysis, five components were identified through PCA, based on the significance of the variables' loadings to the five components. Based on the PCA results, the list of sustainable construction cost determinants was narrowed down and grouped into the five factors:

- Economy of construction
- Contract management
- Project team expertise
- Socio-environmental influence
- Technology and innovation

Moreover, as the quest to develop a sustainable affordable construction model continued, these factors were used to screen the measurement variables that were loaded into the latent constructs in the model.

9.2.4 Identifying Construction Concepts that Enhance Sustainable Affordable Housing Construction

The fourth objective was to ascertain construction concepts that could be used to produce sustainable affordable housing for modelling the sustainable housing construction model. Literatures revealed a lack of environmental building assessment methods, and the need for a multi-dimensional approach in appraisal of construction projects, particularly at construction stage. In the literature, a list of sustainable construction methods and criteria for evaluation was identified and responses from questionnaires were used to rank the principal criteria for measurement to be integrated into the sustainable construction model.

Based on the results of data analysis, Lean concept, Modular construction, Concurrent engineering and Traditional construction methods ranked from first to fourth. The correlation analysis amongst the construction methods to prove the construction method's influence on cost of construction and sustainability shows that Lean concept and Modular construction have a very strong relationship, also traditional construction and Concurrent engineering exhibited a strong relationship. This study thus established that integration of "traditional and concurrent engineering" construction methods will produce housing that is sustainable and cost-effective. On the other hand, "lean concept and modular" construction methods are a perfect combination to realise construction of affordable sustainable housing.

9.2.5 To Develop and Validate an Operational Model for Implementing Affordable Housing Construction to Enhance Sustainability

The fifth objective of this research was to develop and test the effectiveness and usefulness of the operational model for implementing affordable housing construction to enhance sustainability. In order to achieve this objective, the hypotheses listed below were used to investigate the link between the constructs that influence achievement of housing construction project goals:

Hypothesis$_{1a}$: choice of construction method is significant to realising sustainability in affordable housing.

Hypothesis$_{2c}$: There is significant relationship between housing finance system and achievement of project objectives.

Hypothesis$_{3c}$: The social sustainability indicators will exhibit relationship with achievement of sustainable housing construction.

Hypothesis$_{4}$: There is relationship between level of user satisfaction and achievement of project objectives.

To test these hypotheses, a structural model was developed using SmartPLS. The structural model results for hypothesis$_{1a}$ showed a strongly significant and positive relationship between choice of construction method and achievement of the project goal of constructing sustainable housing. This implies that the construction method adopted for the execution of a housing project can contribute immensely to the achievement of sustainable affordable housing. The results on hypothesis$_{2c}$, which sought to establish the relationship between housing financing systems and realising the project goal of constructing sustainable housing, show a positive relationship but not significant. This implies that achieving construction of sustainable housing is related to the housing financing system adopted for the project, but is not a good predictor of sustainable housing construction. Hypothesis$_{3c}$, which was to establish the relationship between social sustainability indictors and achievement of the project goal, shows the existence of a strong and significant relationship between the constructs. This strong relationship implies that enhancing sustainability in housing depends largely on the availability of basic infrastructure, community participation and health and safety measures during construction, as well as engaging the local community in the construction activities during construction. The results of structural model on hypothesis$_{4}$ show that there is a positive relationship between housing satisfaction indicators and achievement of sustainable construction. Though the relationship was not significant, it implies that achieving sustainability in construction of affordable housing is somewhat influenced by user satisfaction, since the project is meant for the people to enhance their socio-economic potentials.

To develop and validate the structural model to enhance sustainability in construction of sustainable affordable housing, all four aforementioned hypotheses were tested and combined to formulate hypothesis$_5$ which read thus:

Hypothesis$_5$: When construction method, mode of financing, construction social sustainability indicator and user satisfaction indicator are combined, construction of sustainable affordable housing is achievable.

This hypothesis was tested through a SmartPLS structural model which affirms the findings of the earlier hypotheses. The results showed that construction method, housing financing system, social sustainability indicators and housing satisfaction indicators are directly related to achieving construction of sustainable housing. Though some of the structural model paths were insignificant, they were positively related. However, the combined predictive strength of the constructs in the structural model shows that approximately 43% of the variation in achieving sustainable housing construction can be accounted for by variables included in the structural model. This indicates a strong predictive power though there are indications of the presence of other variables that needed to be considered in the model.

9.2.6 Concluding Remarks

This thesis has satisfied the aim and the set objectives specified in the introduction of this thesis. The study has:

- Successfully explored the relationship between housing construction and environmental degradation.
- Investigated sustainability awareness and attitudes of South African construction professionals.
- Investigated sustainable construction practices and barriers faced in implementing sustainability in housing construction projects,
- Investigated construction methods and housing financing systems employed for affordable housing projects.
- Extensively explored socio-economic sustainability of affordable housing construction.

- The study has identified four determinants to achieve sustainable development in housing construction.
- Developed and validated a structural operational model for implementing affordable housing construction.

The development of a “Housing construction sustainability enhancement model” (HCSEM) in this study has provided a platform for procedures to enhance sustainability in housing to be carried out in a simplified and most effective way.

9.3 SUMMARY OF RESEARCH

This research was set out to identify and establish those factors that are critical for developing a model to evaluate an affordable housing project’s sustainability. In pursuit of the study focus, current practices in sustainability implementation in building design and construction, and drivers and obstacles in implementation of sustainable design and construction were highlighted. This model incorporated environmental values and socio-economic values into the decision making process to promote sustainable practices in construction of affordable housing. There are diverse approaches to resolve affordable housing problems, which include aspects such as socio-cultural, construction economics and financing, which includes facilitating special financial sources to lower the cost of construction, and urban development and land use, to mitigate the deterioration of the natural and physical environment due to construction activities. All of these have become important considerations in every housing project. Although housing is a major contributor to the economic growth of a nation, it is undesirable if its construction causes environmental deterioration. Hence the need for a holistic assessment model to enhance sustainability in housing construction.

Subsequently, the main focus of this research was to develop a structural model to deal with fears in the adoption of sustainability in construction of affordable housing. The structural model is a composite model to evaluate the environmental performance of different construction methods, socio-economic impacts as well as the financial requirements. The study involved identifying the principal sustainable development determining factors, establishing a method of quantification and finally combine the determining factors into a single tool for decision making.

The housing construction sustainability enhancement model is a tool to rate the development option of a project through design consideration, building material selection, construction waste management, social sustainability factors (stakeholders' engagement and available infrastructure to support user needs) and economic sustainability factors. This makes it possible to optimise cost, maximise resources utilisation and minimise damaging effects to the eco-system.

The study was divided into three parts; literature review on sustainable construction awareness in RSA and investigation on determinants of sustainability enhancement in housing development. The literature discussed the impacts of construction activities on the environment. It investigated the housing situation in RSA as well as the RSA sustainable housing development policy. It also investigated the economic aspects of sustainable building development and critically examined the sustainable assessment evaluation tools in use.

From the discussion in the literature review, the sustainable housing construction determinants were identified and form the basis for the formulation of a pilot. industry based survey, affirming the existence of the study problem and to determine the principal variables to be included in the structural model. Further to the literature review and pilot exploratory survey, the study conceptual framework was formulated and also forms the basis for the research design to provide a systematic framework upon which the study was conducted. The research employed a mixed method approach for data collection and analysis, the results of both approaches was triangulated to improve the reliability and validity of the sustainable construction determinants to be included in the structural model. Analysis of the quantitative survey response was carried out using descriptive statistical techniques and PCA, while case by case analysis was used for the qualitative data. The results of analysis revealed the measurement variables to be included in each of the latent constructs in the model.

Lastly, the conceptual model developed was validated using PLS-SEM. The structural model has demonstrated that positive relationships exist between the causal links in the model and the latent constructs have strong predictive powers to enhance sustainability in the construction of affordable housing and other buildings alike. To validate the model, goodness of fit (GoF) values were determined for model fitting, and for validation, the results showed that the model is adequate to predict sustainability in construction processes of housing projects.

9.4 CONCLUSIONS

The primary aim of this research, to develop a housing construction sustainability enhancement model, has been achieved. The structural model for housing sustainability enhancement was presented, discussed and validated. The result indicated that construction method, social sustainability indicators and housing financing have high predictive capabilities to influence achievement of constructing affordable housing that satisfy owners' requirements, minimise capital cost of construction, minimise building cost-in-use and minimise negative impact of the building on the environment, which are the goals of sustainability.

The "sustainability enhancement model" have create the possibility to use a composite model to incorporate construction activities, project finance and social factors, that cannot be measured by other evaluation methods such as BREEAM, CBA, MCA and LCA (see Chapter 2) into evaluation of building sustainability. Another achievement of this research was using PLS-SEM to develop and validate the sustainability enhancement model for decision making. PLS-SEM is a multi-dimensional modelling method and has been proven to have a high capacity to predict performance of complex exploratory variables, hence the generalisation of the adequacy and validity of the model for evaluating sustainability of construction projects. The sustainability enhancement model also provides an opportunity for community participation in the planning process of affordable housing projects. This is another area which most sustainability evaluation frameworks are lacking.

The study provides indicators that will be the baseline for assessing sustainability in affordable housing construction in the future. The sustainability enhancement model can be used as the basis for benchmarking housing construction, to allow decisions to improve the quality of the built environment that is made. The development of the model helps to make better decisions, as the study integrates different perspectives to understand the housing problem in South Africa and developed improved strategies to lead to sustainable-affordable housing construction. There is, therefore, no doubt that a better decision could be arrived at that will improve the overall quality of the built environment through the model.

The findings on housing finance have prompted the study to affirm that a viable decision on strong commitment on the part of a prospective home owner through savings, to housing funds to cushion payment default, will give the home buyer leeway to decide on a housing type of their choice. On the housing provider's part, this strong commitment from the prospective home owner will spur delivery of a quality and sustainable house as a final product.

9.5 PRACTICAL IMPLICATIONS AND RECOMMENDATIONS

Sustainable development is of growing importance to the world because the current exploitation and uncaring use of resources, together with attendant pollution generated from construction activities, cannot continue at its present rate. Housing being the largest construction investment that both the government and private sector is engaged in due to its importance to social-economic growth, the development of a housing sustainability enhancement model is a significant contribution to enhance sustainable development in affordable housing construction. The model will have an important part to play in the future to ensure that sustainability is achieved in construction of housing.

The study shows that if sustainable construction is to be achieved, long-term sustainable strategies must be adopted at the inception stage, design stage and construction stage of a development, to promote environmental protection and conservation and ensure efficient use of human resources. These strategies must focus on continual improvement through the consideration of socio-economic, technological and environmental matters in the decision-making process. Thus, a higher priority must be placed on environmental considerations of housing projects and ensure that the concept of sustainability is valued and rewarded as well as practiced at all levels throughout the project's life.

The study has also provided insights for government agencies, construction professionals (consulting firms), housing developers and contractors on how to measure, check and improve the performance of their organisations in terms of developing sustainable housing. The study has proposed allocation of responsibility to various stakeholders to ensure that the appraisal of every aspect of the development is sufficiently implemented.

The benefits of using a benchmark system for appraisal are evident in other industries, the potential benefits may also be gained in construction. It is therefore important for the construction industry to establish a benchmark system to assess buildings' sustainability performance. The development benchmark system in construction relies solely on the participation and cooperation of the practitioners in the construction industry. Hence, the construction industry needs to establish a more co-operative approach to research and development and to promote more sustainable practices in housing development's design processes and site operations.

Based on the findings and the practical implications emanating from this research, the following recommendations would be made to offer direction to practitioners in affordable housing development towards improving sustainable practices:

- In order to enhance sustainable construction practice, the assessment of the environmental performance of a housing project is largely voluntary, it is important for the regulatory authorities to assist by increasing the statutory requirements for sustainable performance in the design and construction of a project.
- It is recommended that existing policy framework for affordable housing must enforce use of building materials that enhance reduction in operating cost for affordable housing construction.
- It is also recommended that to effect efficient sustainability assessment, it is important to develop a computer application of the housing sustainability enhancement model; this will provide an alternative way to improve sustainable development and, by making it publicly available, to simplify the evaluation process.

In summary, this study has demonstrated that enhancing sustainability in affordable housing is important to achieve sustainable development and sustainable performance of building and facilities in construction. In ensuring the creation of a healthy built environment, proactive strategy is essential for ensuring a superior environment for future generations.

9.6 CONTRIBUTION TO THE BODY OF KNOWLEDGE

The prime objective of this research was to bridge the gap identified in the concept of sustainability in affordable housing construction in developing countries, in order to develop improved strategies to meet the housing needs of economically weaker sections of the population. A novel structural model has been developed, to integrate the four equally significant and interdependent objectives of sustainability, concerning socio-cultural, economic, technological and environmental factors.

A major contribution of this research is the development of the sustainability enhancement model and its application on various aspects of housing construction, creating a comprehensive approach encompassing the different objectives of sustainable affordable housing. This study integrates different perspectives to understand the housing problem in South Africa and to develop improved strategies to lead to sustainable affordable housing. This perspective combines a technological outlook mainly concentrating on construction method with non-technological aspects; social and economic aspects of building process. By integrating this in one model, the study has made a giant contribution to the study of sustainability in affordable housing.

Another major contribution from the study is the use of “Partial Least Square Structural Equation Model” (SmartPLS-SEM) to develop the structural model for enhancement of sustainability in housing construction process. This model was validated in part and as a whole through hypothesis testing. The suitability of PLS-SEM was attested by Robin (2012), that PLS-SEM is a strong method for research that intends to refine theories in management research because it offers various usage advantages. This technique is yet to be extensively employed in construction management research, like other fields. However, this study has shown that PLS-SEM is a key multivariate method of analysis that can be used in the study of housing and sustainability in modelling relationships of variables.

Thus, this research has contributed to existing knowledge by presenting a structural model which provides indicators for construction organisations, housing developers and government agency to harness both technological and socio-economic parameters to improve the affordable housing construction process.

9.7 LIMITATION OF THE RESEARCH

The research carried out in this study is significant and the findings from the study are useful to housing developers and construction stakeholders in their quest to achieve sustainable housing construction. However, the research is not without its limitation. These principally relate to identifying sustainability enhancement determinants in building construction using questionnaires administered to construction industry professionals, housing developers and government agency in South Africa. This therefore is a limitation, since the results may only be valid for the South African context, though the generic methodology, data analysis techniques and the model can be replicated for other countries.

In this study, a number of variables have been employed as alternates for the assessment of the constructs included in this study that may not be perfect measure, since theoretical views never have absolute indicators. Although some of the variables have been validated empirically in previous research, that does not constitute absolute assurance that the variables are flawless. In addition, socio-economic, environmental and technological variables identified in this research may be confined to the time of the research, as people's perception of sustainability awareness and conditions may change over time.

Finally, it is appreciated that the model developed in this study was validated empirically, further validation tests would be required, using sampled projects for data gathering and comparing them to the results obtained from the model in order to establish the nexus between housing financing system, construction method, socio-economic indicators and realisation of project objectives. This is recommended as further research.

However, it is acknowledged that there was time, administrative and financial constraints. Despite all of that, the importance of the study remains, for the limitations do not detract the researcher from the aim of the study, but merely provide scope for further research.

9.8 SUGGESTIONS FOR FURTHER RESEARCH

As indicated in the findings and limitations of this study highlighted in the preceding sections, it is essential to identify possible areas for further research efforts to expand and modify the findings in this research:

- The study investigation has identified four principal determinants that can enhance sustainability in housing construction projects. However, some observations indicated the need for further investigation during the study but outside the scope and aim of the research. Hence, the in-depth investigation that many of the issues warranted was not possible, thus further research is necessary in those areas.
- Further investigation need to be carried-out using a model building and a conventional building type to establish differentials in the construction cost and running cost of the two building types.
- Research efforts should also be directed to establish the social impacts of constructing vertical apartments for low-income population in relation to running cost and economic sustainability of maintaining the building.

- Investigate further the trade-off principle employed in project appraisal for both private and public projects, and to recommend ways of identifying trade-off to suit different project objectives.
- Another area for further research is to examine affordable housing energy usage from a financial viewpoint. The study discovered that energy saving is an important factor that enhances user satisfaction in affordable housing. Therefore, a further investigation into this through energy analysis of a building on life-cycle approach will provide a more accurate analysis with cost implication of building sustainable housing.

9.9 CONCLUDING SUMMARY

The prime objective of the research was to develop a sustainability enhancement model for housing construction projects and the model has been successfully developed and validated. The study established the relationships among the constructs included in the study and the nature and strength of the relationships were identified. The overriding conclusion from the foregoing is that, sustainable construction in affordable (low-income) housing is achievable if; an appropriate construction method is employed, social sustainability indicators are taken into consideration at all stages of construction and an appropriate housing financing system is engaged.

Further to this, the study has made a significant contribution to housing and sustainability literature in construction by using PLS-SEM in developing a structural model for predicting housing project performance, which many of the previous researchers in this area have never used. The research, whilst completed at this stage, has opened up opportunities for further research in many other areas. The findings in this study can be further extended and modified to accomplish the ultimate goal of promoting and improving sustainable practices in construction.

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APPENDIXES

Appendix A: Sample of consent form

Cape Peninsula University of Technology

Bashir Olanrewaju GANIYU (DTech Candidate)
Cape Peninsula University of Technology
Room 2.29, Old Business Building
Bellville Campus,
Symphony way, 7535,
Cape Town.
Cell: +27 61 936 2074
Email: 213314355@mycput.ac.za.

CONSENT FORM

Title of the research project: Sustainable development practices in construction of affordable housing in South Africa

Name and position of the researcher;

Bashir Olanrewaju GANIYU, PhD candidate, Civil Engineering Department, Cape Peninsula University of Technology

Please tick box

1. I confirm that I have read and understand the information the researcher is seeking for in the above study and have the opportunity to ask questions. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without offering reasons. ☐

3. I agree to take part in this study ☐

Name of participant (on behalf of the company) Date ………. …Signature ………

Bashir Olanrewaju GANIYU (researcher) Date ………….. Signature ………

Note: that all the information provided by you will be treated in the strictest confidence. The result will be presented in aggregate format and no any individual disclosure will be made.

Appendix B: The study questionnaire

Civil Engineering Department,
Faculty of Engineering,
Cape Peninsula University of Technology
Symphony way Bellville, 7535.
E-mail: 213314355@mycput.ac.za.
July 2015.

Dear Sir/Ma,

RESEARCH ON SUSTAINABLE DEVELOPMENT PRACTICES IN CONSTRUCTION OF AFFORDABLE HOUSING IN SOUTH AFRICA

The Faculty of Engineering of Cape Peninsula University of Technology (CPUT) is sponsoring a Doctoral (PhD) research aimed at developing strategies for sustainable affordable housing with a view to integrate sustainability concepts in the construction process.

This questionnaire is a significant part of the research project. We do appreciate that the questionnaire will take approximately 20 minutes of your precious time but without your kind and expert input, the research objectives cannot be realised.

Kindly accept our utmost assurance that all answers and information's provided shall be treated with utmost confidentiality and used for academic purposes only.

Should you have any question(s) or would like further information, please do not hesitate to contact me on 061-936-2074 or email at 213314355@mycput.ac.za.

Thank you very much for your valuable time to answer the questions and for your kind assistance.

Bashir O. Ganiyu
(Doctoral Research Student)

Section A. General Information (Please tick √ appropriate option)

1. Type of organisation you work for? (Please tick √ appropriate option) Architecture & design firm ☐ Building Contractor ☐ Government agency [Department of Housing ☐ Department of Human Settlement ☐] Others (please specify)……………………………….
2. Type of building project executed? (Please √ thick all that is applicable) Residential ☐ Commercial ☐ Institutional ☐ Industrial ☐ Others (Please specify)…………………………………………………….
3. Please give an indication of the size of organisation where you work in terms of cidb rating? (Please specify) ………………………………
4. Your regular client type? (Please √ thick all that is applicable) Public Sector ☐ Private Sector ☐ Private Client ☐
5a. Kindly indicate the province where your organisation operates (please thick all that is applicable): Eastern Cape ☐ Free State ☐ Gauteng ☐ KwaZulu-Natal ☐ Limpopo ☐ Mpumalanga ☐ Northern Cape ☐ North West ☐ Western Cape ☐
5b. Government employee, kindly indicate the province where your organisation is based (please thick applicable option): Eastern Cape ☐ Free State ☐ Gauteng ☐ KwaZulu-Natal ☐ Limpopo ☐ Mpumalanga ☐ Northern Cape ☐ North West ☐ Western Cape ☐

Section B: Sustainability awareness, Identifications of constraints in achieving user requirements in housing and the problems of implementing sustainable construction

B.1: Environmental Awareness on construction activities (Please √ thick appropriate option)

1. Please indicate your level of awareness on environmental effects during building design?
Not aware ☐ slightly aware ☐ somewhat aware ☐ moderately aware ☐ extremely aware ☐

2. How would you rate your awareness of environmental impacts during construction of building?
Not aware ☐ slightly aware ☐ somewhat aware ☐ moderately aware ☐ extremely aware ☐

3. Kindly rate the following statement within the context of environmental concern for the construction industry (Please √ thick appropriate option on the scale of 1 - 5): 5 = very important …… 1= least important.

	Statements	**5**	**4**	**3**	**2**	**1**
a	Population growth					
b	Understand environmental impacts at inception stage					
c	Desertification					
d	Environmental assessment is an important consideration					
e	Negative treat to environment					
f	Depletion of renewable resources					
g	Depletion of non-renewable resources					
h	Global warming					
i	Deforestation					
j	Water pollution					
k	Air pollution					
l	Destruction of historical buildings					

B2: application of sustainability principles in building design and construction process (Please √ thick appropriate option)

1. How would you rate your knowledge in sustainable building design?

Don't know ☐ insufficient ☐ sufficient ☐ good ☐ excellent ☐

2. What is your level of familiarity with sustainable building materials specification?

Not at all ☐ slightly-familiar ☐ somewhat-familiar ☐ moderately-familiar ☐ extremely familiar ☐

3. Do you consider sustainability assessment of building materials in building design?

Yes ☐ No ☐

If yes, how is the assessment being done: ……………………………………………………………….
………
If No, please give reason (s) ……………………………………………………………………….
……………………………………………………………………………………………………...

4. What percentage of building project you have executed involve sustainability consideration? (tick appropriate option)

Less than 10% ☐ 11 – 20% ☐ 21 – 30% ☐ 31 – 40% ☐ above 40% ☐

5. How would you rate the following as they affects user requirements in housing construction (tick appropriate option on the scale of 1 - 5): 5= highly significant ……… 1= extremely not significant

	Factors	**5**	**4**	**3**	**2**	**1**
a	Budget constraints					
b	Cost of eco-friendly building materials					
c	Lots of manpower and time in analysing & selecting proper construction method					
d	Building aesthetics					
e	Lack of relevant information on available sustainable materials					
f	Household size					
g	Building user's access to Medical facilities					
h	Energy savings electrical appliance					
i	Sustainable building materials not aesthetically pleasing					
j	Privacy from neighbours					
k	Water savings sanitary and plumbing appliance					
l	Neighbourhood social-economic status					
m	Building forms					
	Others (please specify)………………………………………………………………… ………………………………………………………………………………………					

6. Kindly rate your perception of sustainability through the following statements (tick appropriate option on the scale of 1 - 5): 5 = strongly agree ……….. 1 = strongly disagree

		5	4	3	2	1
a	Guides for selecting sustainable materials is available					
b	Sustainability only satisfy mandatory requirements					
c	Use of sustainable construction methods and materials help preserve the environment					
d	Sustainability is given more consideration by my co-workers in their design					
e	Environmental friendly materials will increase construction cost and time					
f	Use of environmental friendly materials will reduce construction cost and time					
g	Clients want sustainability concept to be applied in their project despite the increase in cost and time					
h	my co-workers applied sustainability concepts in their design and construction of projects despite cost and time increase					
i	Life cycle assessment of construction materials is important					

7. What obstacles currently prevent the use of sustainable products in construction of housing? (tick appropriate option on the scale of 1 - 5): 5 = extremely important ……. 1= extremely not important

		5	4	3	2	1
a	Lack of information on sustainable construction materials					
b	Maintenance concern					
c	Building standards restrictions					
d	Difficulties in balancing environmental, social and economic issues					
e	Perception of extra cost being incurred					
f	Perception of extra time being incurred					
g	Perception that the building will not be aesthetically pleasing					
h	Low flexibility for alternative or substitutes					
i	Unwillingness to change the conventional way of specifying building materials					
j	Lack of adequate and experienced labour to execute the construction works					

Section C: identification of housing financing strategy that promote affordable housing projects and evaluation of factors that affect the construction cost of sustainable housing.

C.1: Identify effective housing finance mechanism at design stage of sustainable housing projects to ensure affordability of housing constructed.

C1.1. kindly indicate the significance of employing housing financing strategy defined below to achieve the objective of constructing housing/residential building projects at affordable cost to the end-user by your organisation using the scale below on scale of 1-5. (5 = always ……….. 1 = never)

Description of Housing Financing strategy/mechanism; • **Down-payment grant**: An interest free loan due to homebuyer at the sale of the home						
	Housing financing strategy (Down-payment grant)	**5**	**4**	**3**	**2**	**1**
A	It strengthens commitment to deliver high quality in constructed facility					
B	It encourages end-user participation in housing development					
C	Responsiveness to reduction in payment default by the homeowner					
D	The behaviour that potential homebuyer must save 10 or 20% helps to manage mortgage payments					
E	Achieves government goal of providing free housing					
F	Enhances delivery of affordable housing using sustainable building materials and construction method					

Description of Housing Financing strategy/mechanism; • **Mortgage payment subsidies**: is a tax free mortgage revenue bonds sold to investors in order to finance housing development below market interest rate mortgages						
	Housing financing strategy (Mortgage payment subsidies)	**5**	**4**	**3**	**2**	**1**
A	Enhances delivery of affordable housing using sustainable building materials and construction method					
B	It encourages end-user participation in housing development					
C	Responsiveness to reduction in payment default by the homeowner					
D	It strengthens commitment to deliver high quality in constructed facility					
E	Achieves government goal of providing free housing					
F	Access to mortgage with little payment support					

Description of Housing Financing strategy/mechanism; • **Mortgage interest deduction**: It's a subsidy for homeownership delivered through deduction of mortgage interest from taxable income						
	Housing financing strategy (Mortgage interest deduction)	**5**	**4**	**3**	**2**	**1**
A	Enhances delivery of affordable housing using sustainable building materials and construction method					
B	It encourages end-user participation in housing development					
C	Responsiveness to reduction in payment default by the homeowner					
D	It strengthens commitment to deliver high quality in constructed facility					
E	Achieves government goal of providing free housing					
F	Access to mortgage with little payment support					

Description of Housing Financing strategy/mechanism; • **Subsidies**: financing option aimed to lower the initial purchase price, monthly repayment and providing down payment assistance						
	Housing financing strategy (Subsidies)	**5**	**4**	**3**	**2**	**1**
A	Enhances delivery of affordable housing using sustainable building materials and construction method					
B	It encourages end-user participation in housing development					
C	Responsiveness to reduction in payment default by the homeowner					
D	It strengthens commitment to deliver high quality in constructed facility					
E	Achieves government goal of providing free housing					
F	Encourages resell of the home by the buyer below market price					

Description of Housing Financing strategy/mechanism; • **Credit enhancement**: issuance of guarantee to homeowner to lower the cost of borrowing and enhance the credit-worthiness of the homeowner/developer						
	Housing financing strategy (Credit enhancement)	**5**	**4**	**3**	**2**	**1**
A	Enhances delivery of affordable housing using sustainable building materials and construction method					
B	It encourages end-user participation in housing development					
C	Responsiveness to reduction in payment default by the homeowner					
D	It strengthens commitment to deliver high quality in constructed facility					
E	Achieves government goal of providing free housing					
F	Access to mortgage with little payment support					

C.2. Kindly rate the influence of these factors on cost of housing construction on a scale of 1 - 5 using the following; 5 = very high influence cost of construction ….. 1= very low influence on cost of construction.

Nature of the influence: if the influence is positive, please put (+) sign, if the effect is negative (-) sign.

	Factors influencing cost of construction	**Influence**				
		5	**4**	**3**	**2**	**1**
	Environmental factors					
1	Effect of weather					
2	Energy usage during construction					
3	Project location					
4	Use of natural building materials					
5	Use of modern building materials					
6	Tax incentive on implementation of sustainable construction practice					

7	Availability of skilled Labour within the project vicinity					
	Construction parties related factors					
8	Incorrect planning					
9	Lack of coordination					
10	Design consideration					
11	Material standard					
12	Financial control on site					
	Construction related factors					
13	Contract management					
14	Contract procedure					
15	Change in design					
16	Contract period					
	Cost estimating factors					
17	Cost of materials					
18	Cost of labour					
19	Cost of machinery					
20	Allowance for waste					
21	Lending/interest rate					
	Financing factors					
22	Mode of financing bonds and payments					
23	Inflationary pressure					
24	Exchange rate					

Section D: influence of construction methods and assessment of social indicators on affordable housing construction

D.1. how would you rate the importance attached to the following project objectives of building projects? (tick appropriate option on the scale of 1 - 5): 5 = extremely important …….. 1 = extremely not important.

	Statements	**5**	**4**	**3**	**2**	**1**
a	Satisfy building regulation requirements					
b	Satisfy client specification					
c	Minimise capital cost of construction					
d	Meet project time duration					
e	Minimise building cost-in-use					
f	Minimise building impact on the environment					

D.2: assessment of construction methods that support sustainable construction in building development

D.2.1. to what extent does the construction methods defined below support sustainable construction and kindly give an assessment of level of preference of each factor in housing construction. Rating scale; 5 = extremely importance, 1= extremely not important. Preference: 3 = highly preferred …. 1 = less preferred.

		Importance level					**Preference**		
	Construction methods/concepts (Traditional Method)	**5**	**4**	**3**	**2**	**1**	**3**	**2**	**1**
1	Simplicity of construction								
2	Minimise materials wastage								
3	Contribute to depletion of natural environment								
4	Flexibility in construction								
5	Require more space for construction activities								
6	Minimise cost of construction								
7	Ease of adaptation								

		Importance level					**Preference**		
	Construction methods/concepts (Concurrent Engineering)	**5**	**4**	**3**	**2**	**1**	**3**	**2**	**1**
1	Promote integration of two or more construction methods								
2	Eliminate materials wastage								
3	Enhance construction speed								
4	Flexibility in construction								
5	Increase quality								
6	Minimise use of space for construction								
7	Minimise construction expenses								

		Importance level					**Preference**		
	Construction methods/concepts (Modular construction)	**5**	**4**	**3**	**2**	**1**	**3**	**2**	**1**
1	Rigidity in construction								
2	Avoid materials wastage								
3	Reduce use of non-renewable materials								
4	Optimise building design								
5	Minimise use of space during construction								
6	Minimise cost of construction								
7	Improve quality of output								
8	Prevent pollution								
9	Reduce construction time								

		Importance level					**Preference**		
	Construction methods/concepts (Lean concept)	**5**	**4**	**3**	**2**	**1**	**3**	**2**	**1**
1	Minimise negative impact on the environment								
2	Avoid materials wastage								
3	Increase quality								
4	Enhance flexibility in construction								
5	Minimise use of space for construction activities								

6	Minimise cost of construction								
7	Ease of adaptation								

D.2.2: Level of impact on cost of construction and sustainability enhancement in building construction
Scale; 5 = very high influence …….. 1= very low influence
Nature of the influence: if the influence is positive, please put (+) sign, if the effect is negative (-) sign.

Evaluate your overall perception of the significance of these methods of construction on "cost per unit of housing" and sustainability enhancement		**Influence on cost of housing**					**Influence on sustainability**				
		5	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**
1	Traditional construction method										
2	Modular construction method										
3	Concurrent Engineering										
4	Lean concept										

Section E: Social sustainability indicators

The under-listed are identified social sustainability factors that affects construction projects at inception, design and construction phase.
E.1- Kindly rate the importance attached to these factors at inception stage of housing construction project and choose among the stakeholder's who is to be responsible for the execution of the task (please thick appropriate option). Rating scale: 5= extremely important ……. 1= extremely not important;
Responsibility allocation: X= Government, Y= Consultant & Designer, Z= Contractor

Description of Social Indicators at inception stage;

- Stakeholder's Engagement: User's expectations of with regards to project success and corporate social responsibility
- Cultural impacts: Due consideration for impacts of the project on cultural, historical heritage and ethnic identity of the targeted community
- Local community status: social class of the community, employment and business
- Household size: average household size and population of people in the community
- Health and safety: assessment of potential health and safety risk to the public and project users
- Infrastructural development: additional infrastructure needs such as power, roads, rail, transportation, education and medical
- Corporate social responsibility: selection of design and construction firms with acceptable track record to social sustainability

	Social sustainability factor at inception stage	**Rating scale**					**Allocation**		
		5	**4**	**3**	**2**	**1**	**X**	**Y**	**Z**
1	Stakeholder's Engagement								
2	Cultural impacts								
3	Local community status								
4	Household size								
5	Health and safety								
6	Infrastructural development								
7	Corporate social responsibility								

D.2- Kindly rates the importance attached to these factors at design stage of housing construction project and choose the stakeholder who is to be responsible for the execution of the task

Description of Social Indicators at design stage;

- Stakeholder's Engagement: Engaging with representative of local community, community associations and end-users affected by the project and informing them about the project constraints and impacts
- Social Equity: Selection of design team among the diverse races.
- Considering cultural needs in Architectural Design: introducing features to suit spiritual needs, comfort and relevance with the environment
- Sense of communal interactions: provisions of facilities that encourage social activities and human interactions in the community
- Health and safety design: Due considerations to health and safety requirements through emergency response, security alarms, ventilation and air quality
- Building operation cost: Consider reduction in the operating cost of the facility in the design
- Protection of Natural Habitat: protecting biodiversity of surrounding natural habitat
- Public Accessibility: Access to public transit, safe pedestrian walking route and green spaces

	Social sustainability factor at design stage	**Rating scale**					**Allocation**		
		5	**4**	**3**	**2**	**1**	**X**	**Y**	**Z**
1	Stakeholder's Engagement								
2	Social Equity								
3	Considering cultural needs in Architectural Design								
4	Sense of communal interactions								
5	Health and safety design								
6	Building operation cost								
7	Protection of Natural Habitat								
8	Public Accessibility								

D.3- How would you rate the importance of these factors at construction stage of housing projects and indicate the stakeholder that is responsible to execute the task

Description of Social Indicators at construction stage;

- Employment opportunity: Creating jobs for construction workers, professionals in the construction industry
- Use of local resources: Locally sourced Materials and human resources
- Equitable Social Services: Providing services for all social classes (such as people with disability, the elderly as well as racial groups)
- Social-economic Upliftment: Social impacts on economic changes, distribution of benefits and losses among project staff
- Community Participation: Improving public involvement in project selection, monitoring and control through public participation and control through regular communication
- Minimising neighbourhood disturbances: Disruption caused by the construction process (dust, noise and traffic congestion)
- Health & Safety in Construction: Training, counselling, prevention and risk-control programmes as well as facilities, insurance, warning boards and signal systems
- Enhancing Job Satisfaction: Improving motivation, competition, productivity and satisfaction of team members through Management/Owner/representative commitment

	Social sustainability factor at Construction stage	**Rating scale**					**Responsibilities allocation**		
		5	**4**	**3**	**2**	**1**	**X**	**Y**	**Z**
1	Employment opportunity								
2	Use of local resources								
3	Equitable Social Services								
4	Social-economic Upliftment								
5	Community Participation								
6	Minimising neighbourhood disturbances								
7	Health & Safety in Construction								
8	Enhancing job satisfaction								

Section F. Background of Respondent

Name of organisation (optional):

Position in organisation:

Years of working experience: (please tick √ appropriate option)

0 -5 years ☐ 6 – 10 ☐ 11 – 15 ☐ 16 – 20 ☐ above 20 ☐

Address (optional):

Telephone (optional): E-mail (optional):

Thank you.

Appendix C: Invitation letter and Interview appointment schedule

Cape Peninsula
University of Technology

Civil Engineering Department,
Faculty of Engineering,
Cape Peninsula University of Technology
Symphony way Bellville 7535
E-mail: bashalaanu74@gmail.com
Date:………………….

Dear ......,

Letter of appreciation and request for interview appointment

I write to express our appreciation for finding time out of your busy schedule to respond to our research questionnaire survey. We also appreciate your readiness to be interviewed on the subject of the research as indicated in your response to our research questionnaire survey. Thank you very much.

Sir, to achieve robust findings, the research phase is divided into "Quantitative and Qualitative Phase". Quantitative questionnaires survey has been carried out and preliminary analyses of the data obtained had revealed some facts. Therefore this interview is set to find answer to some salient questions on the preliminary results obtained from the quantitative phase and to affirm the facts obtained to ensure validity and reliability of the research outcomes.

I wish to request for an appointment for the research interview. Kindly specify a date and time that will be convenient for you between 25th August and 4th September 2015 through the email address provided in the signature.

Sir, I wish to state that the objectives of this research will not be realised without the valuable contribution from your vast experience in the construction industry.

I wish to state that all information you provided during and after the course of the interview shall be treated with all anonymity and confidentiality.

Thanks for the usual and anticipated support.

Bashir O. Ganiyu
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Appendix D: Interview guide

Cape Peninsula University of Technology

Title: **Strategies for affordable housing construction to enhance housing sustainability in South Africa**

<u>Interview guide</u>

1. How could environmental sustainability be ensured in building projects, as it influence;
   - Design consideration,
   - Building material selection,
   - Construction method,
   - Construction waste management.
2. To ensure economic sustainability of housing by making it affordable and sustainable, construction companies often initiate novel management practices such as fast tracking, lean construction, etc.
   - Which management practices could be used to enhance affordability of mass-housing projects?
   - How can cost of housing construction be reduced to encourage the use of energy saving appliance in low income housing?
3. What are your thought about the use of alternative building materials for construction of affordable housing in terms of;
   - cost of construction,
   - acceptability, and
   - life of the building?
4. What are the rating criteria necessary to access building sustainability?
5. What methods of housing finance are appropriate for affordable housing construction projects?
6. Do you agree that if a building is sustainable and economically affordable, it will enhance eradication of informal settlements?
   - How can this be done to improve the present housing situation in South Africa?
7. How could the challenges in implementing sustainable construction practices in mass-housing projects be surmounted?