CONTRACTORS' SELECTION CRITERIA FOR SUSTAINABLE INFRASTRUCTURE DELIVERY IN NIGERIA

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DECLARATION

I certify that this thesis is my own work, based on my personal experience and research. All materials and sources used in its preparation, whether they are books, articles, reports, and any other kind of document, electronic or communication, have been acknowledged. I also declared that I have not copied in part or whole or otherwise plagiarised the work of other students and/or persons.

GLOSSARY OF TERMS

AHP: ---------- Analytical Hierarchy Process
ANP: ---------- Analytical Network Process
A21: ---------- Agenda 21
BPP: ---------- Bureau of Public Procurement
BS: ---------- British Standard
BVMN: ---------- Best value model for Nigeria
CATWOE: ---------- Customer-Actors-Transformation-Worldview-Owners-Environment
CR: ---------- Consistency Ratio
CCECC: ---------- Chinese Civil Engineering Construction Company
CPAR: ---------- Country Procurement Assessment Report
CRCC: ----------China Railway Construction Corporation Limited
CSR: ---------- Corporate Social Responsibility
DC: ----------Developing Countries
DFRRI: ---------- Directorate for Food, Road and Rural Infrastructures
EU: ----------European Union
FA: ---------- Factor Analysis
GATT: ----------General Agreement on Trade and Tariffs
GDS: ---------- Group Decision Support
GDP: ---------- Gross Domestic Product
ICB: ---------- International Competitive Bidding
ICRC: ---------- Infrastructure Concession Regulatory Commission
IMF: ----------International Monetary Funds
LCC: ---------- Local Construction Contractors
LCB: ---------- Local Content Bill
MCC: ---------- Multinational Construction Corporations
MCDM: ---------- Multi Criteria Decision Making
MDAs: ---------- Ministries, Department and Agencies
MDBs: ---------- Multilateral Development Banks
MDGs: ---------- Millennium Development Goals
NAPEP: ---------- The National Poverty Eradication Programme
NEEDS: ---------- National Economic Empowerment and Development Strategy
NCCIMB: ---------- Nigerian Content Construction Industry Monitoring Board
NCPAR: ---------- Nigeria Country Procurement Assessment Report
NLC: ---------- Nigerian Local Content
PAP: ---------- Poverty Alleviation Programme
SAP: ---------- Structural Adjustment Programme
SC: ---------- Sustainable Construction
SID: ---------- Sustainable Infrastructure Delivery
SD: ---------- Sustainable Development
SI: ---------- Sustainable Infrastructure

SIRSDEC: ----------The Sustainability Infrastructure Rating System for Developing Countries
SP: ---------- Sustainable Procurement
SPE: ----------Special Purpose Entity
SSM: ----------Soft System Methodology
SPV: ---------- Special Purpose Vehicle
ST: ---------- System Theory
SWOT: ---------- Strength-Weakness-Opportunity-Treats
VM: ---------- Value Management
VfM: ---------- Value for Money

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DEDICATION

For their courage and brilliance, this thesis is dedicated to my witty daughters, JANE and EMMA

ABSTRACT

The research reported in this study developed and validated a framework for the pre-evaluation of contractors for sustainable infrastructure projects through Public-Private Partnership (PPP) in Nigeria. The proposed framework uses the Analytic Network Process (ANP) to select contractors for build-operate-transfer (BOT) contractors.

Theoretically grounded on a system theory, a sustainable infrastructure delivery (SID) model is developed in this research. One of its important features is the ability to solve complex decision problems, typical of a decision-making process that involves selection of contractors for PPP projects. At the deductive phase of the proposed model is the integration of the ANP (multi-criteria decision-making technique) for data synthesis.

An extensive literature review was conducted with regard to selection criteria for contractors. Furthermore, a web-based questionnaire survey was undertaken, aimed at capturing the perception of the Nigerian construction professionals regarding the importance of these criteria for pre-evaluation of contractors for public infrastructure procurement. A total of 143 questionnaires was received and their feedbacks were analysed with the IBM SPSS statistical package. The findings revealed a broad range of 55 relevant criteria that were linked to sustainable contractor selection. Through the application of factor analysis, the number of the criteria was reduced to 16, after multicollinearity issues in the data set had been resolved.

The 16 factors were modelled to pairwise comparison matrices, transforming decision making process from linear to a systemic approach. A purposeful sampling methodology was then applied for the selection of decision-making panel (DM), who completed the pairwise comparison survey. The survey results were synthesised by ANP. The final solution derived order of significance of the two categories of contractors- multinational construction corporations (MCC) and local construction contractors (LCC) in respect to the delivery of a sustainable infrastructure.

Sensitivity analysis of the research findings reveals that the 16 criteria have differential comparative advantages, which requires critical judgement during contractors' pre-evaluation process. Although the overall priorities rank multinational construction corporations (MCC) higher than local construction companies (LCC), it is not absolute that MCC will deliver a better value for money on all tangible and intangible elements of sustainable infrastructure attributes. LCC outperform on some of the key criteria such as local employment creation and local material sourcing, which are essential pre-evaluation criteria.

This research proposes a novel framework to harmonise sustainability indicators in contractor selection and offers a new theoretical insight into the approach to contractors' selection criteria during pre-evaluation process, which contributes to the enhancement of PPP delivery in Nigeria.

Overall, the proposed SID model has demonstrated the need for a shift in the modus operandi of the government's ministries, department and agencies (MDAs) in Nigeria from unidirectional to systemic selection techniques. It clearly demonstrates the appropriateness of the ANP to predict the contractor that will deliver more sustainable infrastructure.

CHAPTER 1 : INTRODUCTION

1.0: Introduction

Sustainable development concept is an important issue in infrastructure delivery due to its implications on social and environmental aspects of the proposed development. Despite the multifaceted nature of construction values, focal attention during contractors' selection for public infrastructure is often based on economic values, with little consideration for environmental values, and in most cases social values are omitted in developing countries (DC). The primary goal of contractors' pre-evaluation process in public procurement is to select contractor that deliver value for money (VfM). The usage of VfM is vague in the literature (Francis et al., 2014; Lee and Barrett, 2006; Male et al. 2005; Perry, 1914). Traditionally, VfM in infrastructure projects used to be gauged mostly on the ability to procure a constructed facility at the lowest cost (Walraven and de Vries, 2009; Palaneeswaran et al., 2003). Therefore, it is very important to reassess the concept of VfM in sustainable infrastructure delivery (SID) context.

Despite growing need for social sustainability in public procurement (EU Directives 2004/18), criteria for selecting contractors for public-private-partnership (PPP) infrastructure projects in Nigeria are limited to economic performance (Babatunde and low, 2013). VfM appraisal being limited to economic expression is the driver for the disparity between economic growth and social development. Despite unprecedented capital investment in infrastructure delivery in Nigeria since 1999 (Fourth Republic), construction supply chain has failed to make a significant job creation for the locals in Nigeria, as evident in unprecedented level of youth unemployment and decline of local manufacturing industries.

There is neither a concesus on the number of criteria nor a generalised theory that underlay contractors' selection criteria (Enshassi et al., 2013). Meanwhile, the methodologies and procedures for pre-qualification evaluation for prospective contractors have been consistent in Nigeria. To predict that a prospective contractor will deliver a sustainable infrastructure, sustainable-based evaluation criteria would be required during pre-evaluation process. This chapter describes the research background, project rationale, aim and objectives, research design, originality of research and thesis organisation.

1.1: Project Rationale and Justification of the Research

Nigeria's economic performance over the past decades preceding the economic reforms agenda of 2003 was generally frightful (Okonjo-Iweala and Osafo-Kwaako, 2007). In 2003, the Nigerian government introduced economic reform programme, known as the National Economic Empowerment and Development Strategy (NEEDS) (Nigerian National Planning Commission) (NNPC, 2004). NEEDS was a panacea policy of the Obasanjo's civil administration of the fourth democratic rule (Okonjo-Iweala and Osafo-Kwaako, 2007) to revitalise the national economy. It was also a comprehensive poverty alleviation programme. The goal of NEEDS was to create macro-economic that supports private investment and promote employment creation. Prior to 1999, governance had been subjected to military rules that was characterised by violence and unpleasant environment for economic activities. The development had subjected economy to unstable condition and created an environment that was less attractive to private investors.

Construction sector has a major role to play in the actualisation of NEEDS agenda through the creation of infrastructure projects that support housing, commerce, transportation, recreation, production, energy, irrigation, water, waste management and other related facilities. Meanwhile, the economic system has already marred with the dearth of infrastructure. The existing facilities are either deficient or poorly maintained. To actualise objectives of NEEDS, therefore, accelerated infrastructure delivery has become paramount. PPP has since become a paradigm shift in infrastructure procurement among government ministries, department and agencies (MDAs). The principal modes of PPP in Nigeria are (BOT) - Build Operate Transfer; (RBOT) - Rehabilitate/Build Operate Transfer; LPM - Landlord Port Model" for the Nigerian ports in line with the ports reform programme; RLOT - Rehabilitate, Lease, Operate and Transfer (ICRC, 2012).

To achieve VfM in infrastructure procurement and sustain infrastructure procurement, MDAs has prioritised open and negotiated bidding system as tender options (BPP, online). The motive is to attract and explore the prospects of construction on a global scale. The '*look east policy*' was initiated by the government, which targeted funding package and wealth of experience of the Chinese Civil Engineering Construction Company (CCECC) (see Babatunde and Low, 2013).

A report by Infrastructure Concession Regulatory Commission (ICRC, 2012) showed that PPP had significantly improved infrastructure delivery (transportation, communication water system etc.) in Nigeria. It also reflected that multinational construction corporations (MCC), notably, CCECC had played leading roles in construction management in Nigeria (Babatunde and Low, 2013). Though government's economic reforms are centred on VfM and sustainability, there is ambiguity in evaluation criteria for on social progress in PPP. Babatunde

and Low (2013) argued that value framework used by the MDAs for evaluating contractors' selection for PPP infrastructure projects was not sustainable. There is no clear social agenda in procurement policy, as prescribed by the Nigerian Bureau of Public Procurement (BPP). Loxley (2013) was less convinced on the performance of PPP towards meeting Africa's 'infrastructure needs. According to Loxley (2013), evaluating value delivery in PPP in Africa, at large, remain mammoth tasks. High confidentiality was observed to be commonly associated with individual projects and with lack of knowledge sharing among countries. Ofori (2001) concluded that construction procurement in DC was a mere 'shopping list', rather than a coordinated series of planned activities. MCC have equally been accused of promoting capitalism and marginalisation in construction supply chain (Du-Plessi, 2007; Loxley, 2013). Studies have equally questioned the effectiveness and efficiency of the local construction contractors (LCC) to deliver quality infrastructure due to lack of fund, poor work ethics, skills deficiency (Fernz et al., 2013).

Thus, same trends of problems and issues, which have been diagnosed over the past decades persist despite number of policies being executed. Most of the formulated policies are mere theoretical, lacking methodological framework for execution. Policy makers are faced with challenges still require support for methodological framework for the implementation sustainable infrastructure policies. Enweremadu (2013, pp. 71), as credited to Goodluck Jonathan (Vice President, the Federal Republic of Nigeria), argued that

> *"the performance of the Nigerian economy in the past four or more years has been remarkable, with a stable macro-economic environment and a growth rate averaging 6.3%.... However, it is obvious that the associated benefits of growth were yet to trickle down to a large segment of our people…. The challenges of poverty, growing inequality, coupled with increasing graduate unemployment remain worrisome…. We cannot over flog the issue of infrastructural deficit that continues to becloud our investment climate"*

Okonjo-Iweala and Osafo-Kwaako (2007) made a strong case for a reformed procurement policy in public sectors to achieve SD in Nigeria.

While advocates of PPP argued in favour of the needs to improve government's fiscal spending through private funding and effective risk management (Cheung and Chan, 2009), evaluation of social values remains salient during VfM appraisal of PPP in Nigeria and it equally poses risk on the actualisation of SD agenda. Pre-evaluation criteria for PPP contractor selection in Nigeria, therefore, remain one of the key barriers to SID.

Notwithstanding, formulation of pre-qualification criteria for PPP contractors' selection in Nigeria is a complex decision problem, considering the pluralistic nature of construction client in public domain (Checkland and Scholes, 1990). Unlike traditional procurement approach, construction client in PPP is pluralistic and it is best described from stakeholders' perspective, and they include project financial, contractors, government agents and end users. Each of the stakeholders has different views in the evaluation of best value in infrastructure procurement. Equally, an effective management of the stakes has great impact on risk management and sustainability of the procured infrastructure.

1.2: Aim and Objectives of the Research

The aim of this study is to develop a framework for contractors' selection that MDAs in Nigeria can use to achieve value in the delivery of sustainable infrastructure project.

To achieve this aim, the following objectives have been identified:

1) *To investigate current contractors' selection process for infrastructure projects*
2) *To evaluate key procurement methods that can be used for capital projects*
3) *To analyse contractor's selection criteria that support sustainable infrastructure delivery and best value for money*
4) *To determine the level of application of sustainable criteria during pre-qualification of contractors in PPP contracts (including ranking these criteria in order of importance)*
5) *To develop and critically evaluate a novel sustainable infrastructure delivery framework that could be used during pre-qualification stages for contractors involved in PPP projects*

1.3: Research Hypothesis

The key agenda of MDAs is to promote infrastructure funding by private sector, which conforms to the goal of the economic reforms policy as highlight in NEEDS. The report of infrastructure projects shows that, since 1999 (the fourth republican government in Nigeria), private construction contractors, dominated by Multinational Construction Corporations (MCC) have improved the delivery of constructed facilities. To facilitate enabling environment for MCC operations, open competition tendering is applied by government's Ministries, Department and Agencies (MDAs). This is based on the premise that VfM from contractors that offer a competitive price. Invariably, traditional selection criteria still dominate contractors' pre-evaluation exercise. Outsourcing is unrestricted. Contractors could source resources (both materials and human) in places on their choice solely on economic considerations.

In contrast to the economic growth, the national system is characterised with unprecedented unemployment level. The occurrence social vices; kidnapping of multinational workers for ransom and destruction of government facilities during protests, have considerably added to the cost of infrastructure delivery. Inability of construction industry to effectively generate direct and indirect jobs could mean that benefits derived from construction are limited to 'direct benefit (i.e. physical infrastructure). Thus, questions that are remained unanswered are:

1) Do MDAs recognise the scope of construction industry as a key economic sector that can stimulate social development through job creation?
2) What does sustainable infrastructure delivery mean in the context of Nigeria?

In summary, two hypotheses have been proposed:

- *H_1: Public infrastructure procurement does not contribute significantly to job creation*
- *H_2: Public infrastructure procurement does not enhance the growth of construction supporting industries*

The hypotheses are tested using multiple regressions. The analysis is not just to validate the general views, but to expand knowledge but to find potential relationships that are theoretically accepted.

1.4: Scope of Study

Achieving best value in contractor selection for SID is a combination of pre-qualification criteria and bid evaluation. Pre-qualification is aimed at reducing prospective contractors to a reasonable number to be considered for further review. The process involves the design of pre-qualification questionnaire that seek information about the contractors and weigh them against the pre-determined project's value attributes, such as experience and financial capability (depends on the tendering method used, which include open, selective, negotiated etc.). The score card of the contractors enables the client to predict the list of contractors that are most

suitable to be invited for tender submission. Bid evaluation is a post-tender stage activity, and it is basically quantified in monetary terms.

This study focuses mainly on pre-qualification phase of tender process. In the process, sustainable selection criteria for contractor pre-evaluation for PPP infrastructure projects will be theoretically developed. This will be supported with the development of framework that predicts the sustainability of selected contractors.

1.5: Research Design in Brief

Traditionally, pre-evaluation criteria for contractors' selection for infrastructure projects focuses on economic criteria. The genesis of partnering arrangement in public infrastructure delivery could be traced to the report by Egan (1998) on rethinking construction. The report was initiated to find solutions to high cost of construction due to miss management of construction risks and values between client and contractor. It was concluded that VfM could only be achieved when client and contractor jointly manage benefits and risks in procurement process. With the growing knowledge of innovative procurement options and SD, it has since become a practice that holistic measures are required to achieve SID.

Contractors' selection for PPP project in public domain poses multi-criterion challenges due to financial risks that are often bored by the contractor. By considering severe impacts the conflicting interest among construction stakeholders on project success, a holistic approach would be required to structure evaluation process. SID model is proposed in this study in theoretically grounded on the methodological process of action research, which are:

1) formulation of contractors' pre-evaluation criteria that is based on best value principle
2) Application of evaluation technique that take to consideration of the influences that exist among the selection criteria

Generally, action research methodology aims at solving practical and complex problems and it produces guidelines for best practice (Denscombe, 2010). Specifically, SSM by Checkland and Scholes (1990) provided a framework for structuring a multi-criteria decision, such as the theme of this study. The framework emphasised roles of human engagement in the construct of a reality.

1.6: Originality of the Research

To the best of knowledge of the researcher, which was greatly reinforced by extensive literature review, engagement with construction professionals, and peer reviews from global conference proceedings in built environment, infrastructure projects delivery in Nigeria is not sustainable. The pre-evaluation criteria for contractors make ambiguous social elements of procurement. Value for money ideology is centred on the lowest cost approach, with studies on value-added procurement in Nigeria mostly based on economic elements. Whilst construction cost is often weighed on the estimated cost of infrastructure delivery, British standard (BS 8903:2010) and Ogunsemi and Jagboro (2006) argue construction cost from economic, environmental and social perspectives. Little work, if any is known to have been carried out, which investigated pre-evaluation of contractors for PPP infrastructure projects in Nigeria from a social and environmental dimension of sustainability. Hence, this research proposes a novel sustainable infrastructure delivery model to harmonise sustainability indicators in contractor selection and offer new theoretical insight into the approach to contractors' selection criteria during pre-evaluation process, which will contribute to the enhancement of sustainability of PPP delivery in Nigeria.

1.7: Thesis Structure

This thesis consists of 8 chapters as shown in figure 1.1

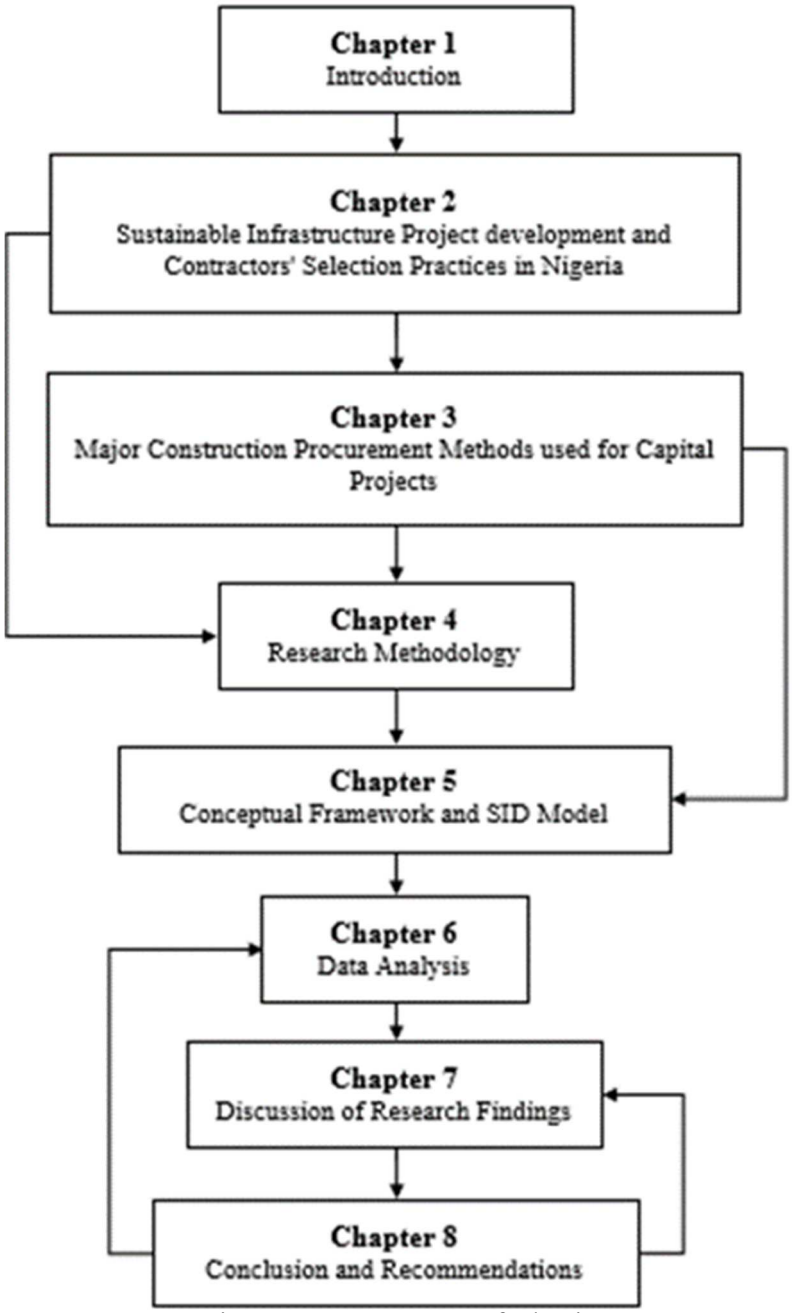

Figure 1-1: Structure of Thesis

Chapter One: Introduction

This chapter provides background information for this study. It explains why this study was undertaken and how this research is significant to social development in Nigeria. Research aim and objectives, and scope of study were highlighted. This chapter also presents a brief of research design.

Chapter Two: Sustainable Infrastructure Project Development and Contractors' Selection Practices in Nigeria

This chapter builds a theoretical foundation for the study by reviewing relevant literatures on sustainable development (SD) and construction activities in Nigeria. The chapter explores Agenda 21 for Sustainable Construction in Developing Countries (A21 SCDC), or simply Agenda 21, with the highlight of where this study is located. The discourse on the general SD principle and rationale for sustainable infrastructure, as a strategy for achieving A21 SCDC, serve as a platform for sustainable infrastructure delivery in Nigeria context. The SID provides a new outlook for the performance measures for the Nigerian economic reforms policy.

Chapter Three: Major Construction Procurement Methods used for Capital Projects

This chapter critically reviews the major construction procurement methods used for capital projects. Since the best practice in procurement is to deliver sustainable infrastructure, the chapter starts with the discussion on sustainable procurement. It is followed with the challenges of benchmarking in public procurement and general ethical issues in construction. Following a brief discussion on procurement strategies for infrastructure project procurement, this chapter elaborates on PPP, with the investigation on its various streams, reasons for the growing popularity of PPP, and its critical success factors. These provide in depth information on PPP being the major procurement strategy under investigation. Finally, a case for PPP infrastructure projects in Nigeria is presented.

Chapter Four: Research Methodology

Following the review of literature in chapter 2, 3, and 4, this chapter develops and explains the methodological process of the research and rationale for research design and methods of data collection and applied data analysis techniques.

Chapter Five: Conceptual Framework and SID Model

Chapter Six presents the conceptual framework, which revolves on Soft System Methodology (SSM) by Checkland and Scholes. The proposed Sustainable Infrastructure Delivery (SID) model is three phased, comprised of inductive, transitional and deductive phases. The chapter also justifies the integration of the Analytic Network Process (ANP) to the proposed SID model.

Chapter Six: Data Analysis

This chapter presents and analysis primary data, regarding development of pre-evaluation criteria for contractors' selection and hypothesis testing. It implores statistical methods and techniques for the presentation of data for easy interpretations.

Chapter Seven: Discussion of Research Findings

A discussion of the implications of research findings is presented in this chapter. It combines both the findings from analysed secondary and primary data. The implications of pre-evaluation criteria of contractors on SD agenda are discussed and evaluated. The chapter further present a case study for the validation of the developed SID model.

Chapter Eight: Conclusions and Recommendations

This chapter briefly summarise the research and conclude on the achievements of research objectives. It makes a distinct of the original contribution this study has made to the social sustainability body of knowledge. Following the summary of limitations of the research, Recommendations for further research are presented.

CHAPTER 2 : SUSTAINABLE INFRASTRUCTURE PROJECT DEVELOPMENT AND CONTRACTORS' SELECTION PRACTICES IN NIGERIA

2.0: Introduction

This chapter discusses sustainable infrastructure project development and contractors' selection practices in Nigeria. Since sustainable infrastructure is grounded in the concept of sustainability, this chapter starts with the overview of sustainable development. It further elaborates on social sustainability as an integral element of SID. The concept of Agenda 21 for Sustainable Construction in Developing Countries (A21 SCDC) is explored and with the highlights of where this study is located. This is followed with the exploration of sustainable infrastructure practice from Nigeria context.

2.1: How is Sustainable Development Understood?

Sustainability is arguably the global most discussed concept, yet, less understood, with no consensus on the interpretation. This is due to differential level of economic, social and environmental development requirements. Hill and Bowen (1997) viewed Sustainable development (SD) as a development endeavour to solve social needs with measures that minimise potential environmental impacts. British Standard (BS 8903:2010) defined SD as: *'an enduring, balanced approach to economic activity, environmental responsibility and social progresses.* The definition of SD given by the World Commission on Environment and Development (WCED, 1987): *"development which meets the needs of the present without compromising the ability of future generations to meet their own needs",* has since become the most accepted definition for SD (Sourani and Sohail, 2011), though still subject to criticism and refinement (Ofori, 1998; Hill and Bowen, 1997). Over 200 definitions credited to SD (Sourani

and Sohail, 2011; Sjostrom and Bakens, 1999) is an evidence of differential views on the interpretation of SD.

Though Sourani and Sohail (2011) and Hill and Bowen (1997) argued that discourse on sustainability have been extended beyond economy, society and environment attributes, extensive literature reviews reveal that 'triple bottom line' remain a simplified approach to sustainability. Table 2.1 is the key issues identified in sustainability.

Table 2-1 Examples of key sustainability issues

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Source: BS 8903:2010

2.1.1: Economic Sustainability

Economic dimension is the capacity of the system to maintain continual improvement of its economic indicators. The philosophy of economic sustainability requires that resources are used efficiently and responsibly. More importantly, economic dimension ensures financial affordability for intended beneficiaries and reinvestment of proceeds (Ashley et al., 2003; Hill and Brown, 1997). More importantly, economic products must be affordable by the end users (Dunmade, 2002).

Economic issues in construction sector of the national economy when there are irregularities in the structure, conduct and performance (Du-Plessi, 2002). Though construction firms in DC are predominantly small, medium and micro enterprises, they are the source of employment for the nearly 90% of construction employment in DC (Du-Plessi, 2002).

2.1.2: Environmental Sustainability

Environmental sustainability focuses on consumption of natural resources at a sustainable rate. Environmental dimension is concerned with the management of the implications of human activities, mostly influenced by economic activities, on ecological system, water, air and land (Hill and Brown, 1997). It also addresses strategies towards efficient use of natural resources and management of environmental impacts that include waste control (Ashley et al., 2003; Du-Plessi, 2002).

One of the key environmental issues in construction sustainability in DC is over reliance on foreign manpower and materials. While the practice has negative implications on social implications, it also has adverse impacts on environmental sustainability.

Promotion of locally sourced materials and service provision are essential to sustain both the environment and economy (Ashley et al., 2003, Du-Plessi, 2002). This significantly reduces embodied energy, which is measured base on the overall energy usage that includes production and transition. Also, the investment in renewable energy will generate clean energy, which preventing further degradation of ozone layer and promote air quality for well-being.

2.1.3: Social Sustainability

Social sustainability is the ability of a social system to achieve a good well-being on a long term. It is a condition and a process that improves community's quality of life. It is associated with adequate distribution of wellbeing for the present and future generation (Thome et al.,

2016; Ashley et al., 2003; Hill and Brown, 1997). This covers issues such as social equity; labour right, human right, community development, health and safety and social responsibility (Sourani and Sohail, 2011). Equity and better welfare package in the form of good wages afford people the opportunity to engage with social insurance to manage uncertainty (Ofori, 1998). Social sustainability makes provision for capacity enhancement and skills acquisition in business practices (Ashley et al., 2003; Du-Plessi, 2002; Hill and Brown, 1997). The concept of social sustainability has come under considerable pressure and threats from globalisation. The ideology of globalisation has been a success for the acceleration of economic growth. Most often, the implications on social sustainability is not quantitatively evaluated in global economies, especially regarding developing economies.

Hill and Bowen (1997) identified key social principles of sustainability to include:

1) *Improvement of human quality of life by providing basic human needs (food, clothing, shelter)*
2) *Provision of social self-determination and cultural diversity in development*
3) *Protection and promotion of human health through a healthy and safe working environment*
4) *Implementation of skills training and capacity enhancement*
5) *Seek equitable distribution of the social benefits of construction and, where this is not achieved in the intended use of a facility; seek to optimize benefits which arise during the construction process, such as employment opportunities.*
6) *Seek intergenerational equity so that significant social, biophysical and financial costs of current construction are not passed on to future generations*

To achieve excellent quality of life and better standard of living, good planning and strategies are required to ensure that economic development is achieved at a pace with no excessive national debt. The developed technology should take into consideration of the level of skills, wealth and the needs of the local people (Lompo and Trani, 2013; Renouard and Lado, 2012).

The highlighted social principles are also drivers of economic sustainability in many outlooks. Equitable distribution of social benefits, most especially, job creation for the local communities is an evidence of a structural strategy to improve the quality of life of the community. In returns, social sustainability drives economic sustenance by creating enabling environment for economic activities. The long-term implications of the capacity building among local skills are the gradual transformation of the system from being consuming economy to producing economy.

Construction sector is globally acknowledged as a catalyst for sustainable development (SD) (Babatunde and Low, 2013; Du-Plessis, 2007). The sector stimulates positive linkages with broader national economic sectors through direct job creation for site activities and indirect job creation through demand for specialised services and manufactured materials (Alzahrani and Emsley, 2013; Babatunde and Low, 2013; Du Plessis, 2007; Egan, 1998). This process accelerates human development and fashions enabling environment for capital investment and economic growth.

Social sustainability in construction sector is a broad concept of employment creation and capacity development. Equally, the sector is characterised with greed, corruption, labour practices and environmental destruction (Du-Plessi, 2002). Consequences of corrupt practice has been linked to sub-standard construction product, high mortality rate on side due to the compromise of risk management on site. The actualisation of social development has posed a huge responsibility on construction industry in developing countries (DC) (Ofori, 2001).

With the growing popularity of PPP in DC, responsive strategies are required in the above key issues to achieve best value for money (VfM) in public infrastructure delivery through collaboration with the private sector. More importantly, inclusion of social sustainability attributes in contractors' pre-evaluation criteria is critical to achieve sustainable infrastructure delivery (SID). Agenda 21 for Sustainable Construction in Developing Countries (A21 SCDC) (Du Plessis, 2002; Sjostrom and Bakens, 1999) rationalised social values as important benchmarks for assessing progress towards SD in DC. Social value focuses on broader economic, social and environmental impacts of construction activities.

Over the past decades, various policies and regulations have been enforced to promote social values in public infrastructure projects in developed economies. For instance, European Union Directives (EU Directives 2004/18) mandates that construction contractors are not pre-evaluated exclusively on their proficiency in the delivery of quality infrastructure, rather they are obliged to demonstrate the contribution of procurement process to social progress i.e. success towards improved political, social and economic structures. In 2013, Social Value Act was introduced in the United Kingdom. The act regulates government agencies to weigh 10 to 20% of tender on social value. The applied social value measurement metric includes the percentage of the locals that would benefits from apprentices and eventually gain full employment with the contractors. These trends demonstrate how the scopes of criteria for contractors' per-evaluation have evolved over time and broadened beyond convectional economic factors (Walraven and de Vries, 2009).

2.1.3.1: Corporate Social Responsibility

Corporate Social responsibility (CSR) is often seen a generosity of a corporation to the host community; a corporation voluntary business strategy, with no strict guideline for execution. Lompo and Trani (2013) viewed CSR strategic as a management technique used by multinationals for their economic advantage. CSR can be likened to stakeholder management from 'utilitarian standpoint' (Lompo and Trani (2013 and Atkin and Skitmore, 2008).

Multinationals are often pressured United Nations agencies and related pressure group to engage in development initiatives (Lompo and Trani, 2013). Kanji and Chopra (2010) defined CSR as a means of operating a business in a socially responsible manner whereby the business:

-undertakes ethical practices in employment and labour by improving workplace

-is involved in building local communities and communicates with concerned communities regarding the consequences of its policies and products

-invests in building social infrastructure

-contributes to a cleaner environment, its protection and sustainability, and

-contributes by way of its corporate governance to economic development at large

The concept of corporate social responsibility (CSR) is now becoming mission statement for multinationals in DC towards SD. Multinationals embrace CSR in order to sustain their security, productivity, as well contribute to SD of the host community (Renouard and Lado, 2012). Studies have proved that there is no consensus view among researchers on the contributions of CSR towards environmental management and employment opportunities in DC (Lompo and Trani, 2013). With the multinationals being the key players in economic management in DC, there is a need for a regulated CSR to achieve sustainability.

Being a self-regulated mechanism, therefore, evaluation of impacts of CSR on human development in DC remains a mammoth task (Renouard and Lado, 2012). However, Kanji and Chopra (2010) developed a model that simplify the interaction between community, workplace, environment and marketplace in CSR policy.

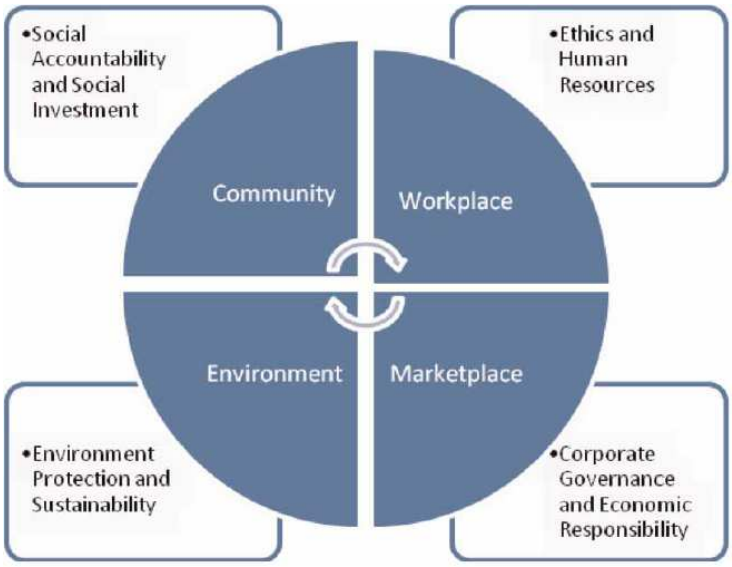

Figure 2-1: Cyclical matrix of corporate social responsibility
Source: Kanji and Chopra (2010)

Figure 2.1 simplifies CSR appraisal to community, workplace, environment and marketplace attributes.

2.2: Agenda 21 for Sustainable Construction in Developing Countries (A21 SCDC)

Agenda 21 for Sustainable Construction in Developing Countries (A21 SCDC), simply Agenda 21, is a recognition of the importance of construction industry towards global SD agenda. Agenda 21 is of two facets, and they are 'brown agenda' and 'green agenda' (Du-Plessi, 2007). Green agenda has been well elaborated in the literatures: it is a response to ecologically detrimental development of an exclusive dependant of humans on non-renewable resources. Brown agenda responds to the problems of poverty and under development. Du-Plessi (2007)

argued that SD can only be achieved when these two agenda are integrated as a developmental strategy. Construction sector has a key role to play in the integration of these two agendas for two reasons: For green agenda, construction extensively depends on natural resources for construction activities and building services. The usage of resources and discharge of waste during construction process, time-in use of constructed facilities and demolition after the facility has complete usable life span have significant environmental impacts. To date extensive research have been conducted on the environmental implications of construction activities. In related to brown agenda, construction process generates significant direct and indirect employment opportunities. In this regard, construction industry is one of the key sectors of the economy that can respond swiftly to job creation, and thereby mitigate poverty. The backwardness of brown agenda is more evident in DC.

Du-Plessi (2007) emphasised that the task of construction sector in DC is not just a panacea to the dearth of infrastructure and housing, but to ensure that construction supply chain is socially and ecologically responsible. There is a growing awareness of the importance of construction activities in DC towards the actualisation of A21SCDC. Figure 2.2 is a timeline of Agenda 21 indicating where this thesis is located.

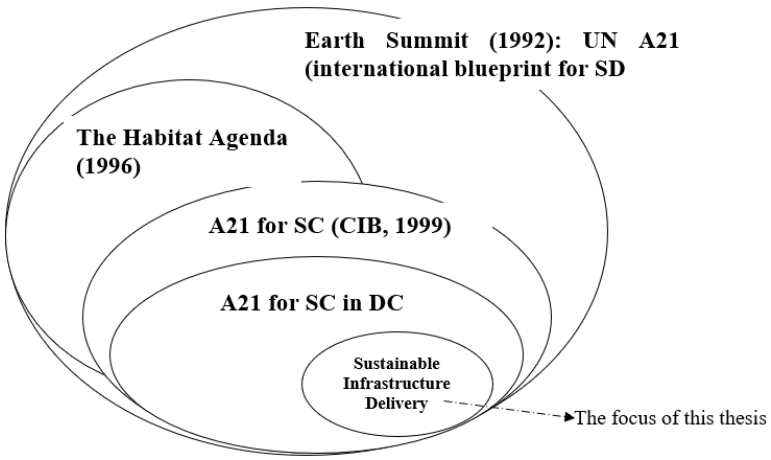

Figure 2-2: A timeline of Agenda 21

Source: Adapted from Du-Plessi (2002)

The timeline indicates why sustainable development has become an important issue in construction industry. It is within the nexus of A21 SCDC that SID is defined. Ever since the formulation of A21 SCDC, attentions have been shifted towards the development of strategies for promoting sustainable construction practice. Yet there is ambiguity in the implementation strategies on how construction in DC responds to the eradication of extreme poverty and hunger.

2.3: Benefits that are Associated with Construction

The activities of the construction industry in public sector comprise procurement and maintenance of civil and building projects, demand for specialised services, equipment, materials, and finance and research development (Sourani and Sohani, 2011; Moodley et al., 2008). To effectively manage social values that are associated with construction activities, knowledge base of benefits that are associated with the process can be understood through the evaluation of the construction supply chain. Whilst project delivery remains a core value of construction sector, PricewaterhouseCoopers (2011) cited in Babatunde and Low (2013, pp. 19) elucidates values enhancement for macro-economic development through the construction industry.

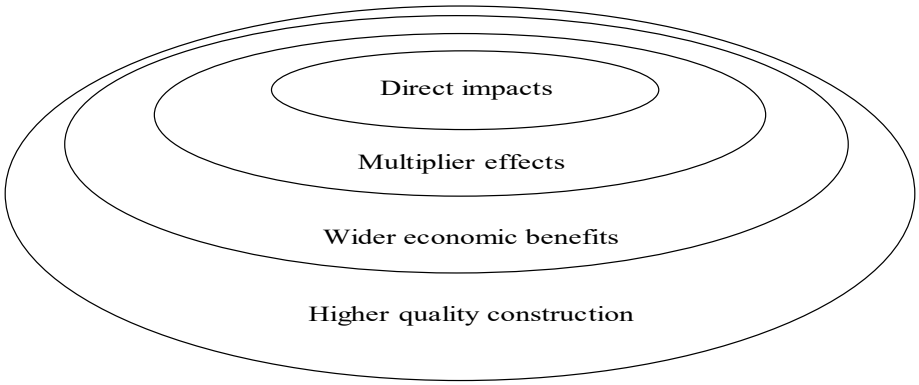

Figure 2-3: Layers of benefits associated with construction

Source: PricewaterhouseCoopers, cited in Babatunde and Low (2013, pp 19)

Figure 2.3 illustrates timeline of benefits associated with construction. At the core of the construction benefits spectrum is the 'direct impacts- this is the basic task infrastructure delivery. The critical decisions that are made on the mode of delivery at the construction pre-construction phase influence on the level of benefits that are derived from infrastructure delivery. 'Multiplier effects' are benefits derived that are related to the creation of job opportunities for the local markets, either through direct labour, sourcing of materials or demand for specialised services. 'Wider economic benefits' are associated with the positive impacts of construction job creation. People are empowered when they are actively integrated to construction roles. In addition, purchasing power and savings culture are greatly enhanced through better welfare packages and incomes that are provided for workers. It also encourages skills acquisition and keenness to innovate is encouraged. These will transform to better performance and growth of construction's supporting industries.

High quality construction is a full-fledged construction industry with all the attributes to compete competitively at a global level. It is a long-term reward for the support for local skills development through research and development. To attain this level, DC requires contractor selection process that is grounded on best value principle that embraces social sustainability. With the formulation of series of planned and coordinated activities in supply chain, progress would be achieved over time (Ofori, 2001).

2.4: Sustainable Construction in Developing Countries

The purpose of a discourse on sustainable construction (SC) is to contextualise SD in construction sector. Acknowledging the fact that SD has been subjected to wide range of interpretations, Hill and Bowen (1997) used the evolution of the concept of SD to make explicit the principles of sustainable construction, which are based on social, economic, biophysical,

and technical frame of references. A discourse on sustainable construction industry in Nigeria and DC, at large, has gained the attention of numerous researchers (Opawole and Jagboro, 2016; Babatunde and Low, 2013; Loxley, 2013; Osabutey et al., 2013; Bakhtiar et al., 2008; Du-Plessi, 2007; Lewis, 2007; Ofori, 2001; Bourdeau, 1999; Kaming et al., 1994).

Table 2-2 A discourse on construction industry in developing countries

Author (s)	Topic	Conclusion derived from reviewed journals
Opaleye and Jagboro (2016)	Factors influencing the scope of private party's obligations in concession-based PPP projects in Nigeria.	Failure of concession–based PPP projects in Nigeria is closely associated to poor definition of the private party's obligations and non-inclusion of sociocultural factors at the pre-construction phase.
Babatunde and Low (2013)	Chinese construction firms in the Nigerian construction industry.	Lack of standardised value framework constitutes a barrier to improving local capacities and creating enabling environment for private sector commitment.
Loxley (2013)	Are public–private partnerships (PPPs) the answer to Africa's infrastructure needs?	Success of PPPs in Africa is non-conclusive. Needs for clear policies, legal framework and technical capacity to evaluate the value for money of PPPs is required.
Osabutey et al. (2013)	The potential for technology and knowledge transfers between foreign and local firms: A study of the construction industry in Ghana.	There is weakness in social value derived from globalised construction in DC in terms of technological transfer.
Bakhtiar et al. (2008)	A framework for comparison study on the major methods in promoting sustainable construction practice.	Despite extensive study on methods for promoting sustainable construction practice, little attention is given to contractor selection as a sustainable construction method.
Du-Plessi 2007)	A strategic framework for sustainable construction in developing countries.	To achieve sustainable construction in DC, there is need for a systemic intervention.
Lewis (2007)	Impact of globalisation on the construction sector in developing countries	DC are not developing, but falling further behind their industrialised counterparts, because of the globalisation of trade (open market).
Ofori (2001)	Indicators for measuring construction industry development in DC.	Infrastructure procurement in developing countries should be more than shopping lists. Performance indicators to include macro, sectoral and project levels.
Bourdeau (1999)	Sustainable development and the future of construction: a comparison of visions from various countries	Though sustainable construction is an important component for creating sustainable development, lack of a clear consensus on the exact meaning of the concept which poses a challenge in the application.
Kaming et al. (1994)	A framework for the strategic development of the construction industry in developing countries.	Governments' economic and implementation policies contribute to under development of human resources in developing countries.

Key issues identified in the discourse of construction industry in DC (see Table 2.2) can be summarised under three broad categories:

1) Ambiguity in the meaning and interpretation of sustainable development concept
2) Non-standardised value criteria for infrastructure procurement with the definition of VfM limited to 'hard values'
3) Unimpressive social sustainable policies and legal framework in procurement practice

A21 SCDC, cited in Du-Plessi (2007) defined SC as:

> *"a holistic process aiming to restore and maintain harmony between the natural and the built environments, and create settlements that affirms human dignity and encourage economic equity"*

The above definition reflects the importance of social principles to achieve SC. The concept of SC is well discussed in literature from DC context, as applicable to Nigeria (Osabutey et al., 2013; Du-Plessi 2007; Dunmade, 2002; Ofori, 2001; Bourdeau, 1999; CIB, 1999; Kaming et al., 1994; Ngowi, 1998). Different acronyms have been used interchangeably with SC in the literature, and they include green building, ecological building, sustainable architecture (Du-Plessi, 2015; Du-Plessi, 2007). These are discernible in typical established methods for promoting SC practice, as discussed Bakhtiar et al. (2008).

Du-Plessi (2002) argued that construction industry in DC had for long time focused on growth rather than embraced the principles of SD, which may mean that, in some cases, it needs to stop growing or grow in different ways. The established methods of promoting SC in DC are biased towards social sustainability as emphasis is mainly on green agenda. Construction needs in Nigerian and DC at large has been limited to reliance on finished products, and this reflects on a cost focused, rather than value-driven concept in infrastructure procurement (Ofori, 2001). The notion, now, is to shift from procuring from sustainable contractors to procuring sustainably. Du Plessis (2007) proposed a strategy for enabling sustainable construction.

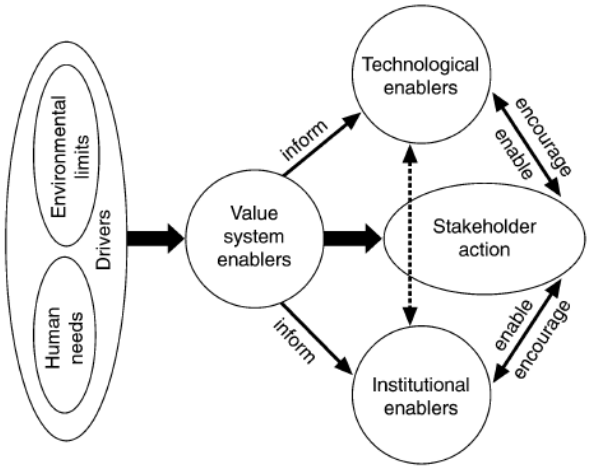

Figure 2-4: A strategy for enabling sustainable construction

Source: Du Plessis (2007)

From figure 2.4, there are three but interdependent and multi-dimensional enablers in SC framework. Developing a strategy for enabling sustainable construction starts with definition of human needs and appraisal of subsequent environmental impacts. To create a balance between the needs and environmental limits, a value system is then developed, and it informs the best way of addressing the conflicting relationship between human needs and environmental conversation.

While technological and institutional enablers are vital to SC, stakeholders' action is very important in the coordination of the system. Du-Plessi (2002) elaborated on the duties of construction stakeholders as follow:

1) *Clients: demand for more sustainable built environment*
2) *Professionals/education sector: to adopt and promote sustainable construction practices*
3) *Construction industry: to commit to embracing sustainable construction process*
4) *Regulatory bodies: to encourage, enable and enforce sustainable construction*

Client

It is the responsibility of the client to formulate attributes to gauge SC. As a guide, key sustainability issues are simplified by the Building Standard (BS 8903:2010) under environmental, social, and economic issues.

Professional/Education Sector

One of the main challenges of the principle of SC is lack of education and awareness among people (Bakhtiar et al., 2008). The education sector is responsible to create more awareness and dispense information in a medium that is more beneficial. The notion that sustainable practice is expensive.

Construction Industry

Construction industry has had a bad reputation for a long time due to resistance to change (Sourani, and Sohail, 2011; Du-Plessi, 2002). Construction business is often not conducted in an ethical manner. For instance, Du-Plessi (2002) stressed the need for a change in construction activities to mitigate environmental impacts. In general, improved performance is expected from construction industry in related to energy consumption during material extraction, processing, construction facility servicing, greenhouse gas emissions and construction waste management. The negative environmental effects of construction activities are more pronounced in DC due to relatively low degree of industrialisation.

Regulatory Bodies

The roles of the regulatory bodies are to encourage, enable and enforce sustainable construction. Weak governance and effective legal and administrative systems are among barriers to SC in DC (Oladinrin and Ho, 2015; Du-Plessi, 2007). The regulatory bodies have huge responsibilities in forming and enforcing guidelines for sustainable practice in construction.

Table 2-3 Typical methods for promoting sustainable construction practice

Code	Methods	Key references
$SC\text{-}M_1$	Education and training	Ekanayake and Ofori (2000); A21 SCDC (2002); Manoliadis et al. (2006).
$SC\text{-}M_2$	Environmental management system	BSI (1994); Hill and Bowen (1997); Ofori (1998); Kein et al. (1999); Shen and Tam (2002); Christini et al. (2004); Yao et al. (2006).
$SC\text{-}M_3$	Green building	Stum (2000); Kibert (2007); Nelms et al. (2007); Kibert (2008).
$SC\text{-}M_4$	Green design	Al-Momani (2000); Ekanayake and Ofori (2000); Begum et al. (2007); Poon (2007); Osmani et al. (2008).
$SC\text{-}M_5$	Green procurement	Ngowi (1998); Rwelamila and Meyer (1998); Ekanayake and Ofori (2000); Ngowi (2000); Rwelamila et al. (2000); Teo and Loosemore (2001); Sterner (2002); Carter and Fortune (2008).
$SC\text{-}M_6$	Green roof technologies	Nelms et al. (2007).
$SC\text{-}M_7$	Lean construction	Huovila and Koskela (1998); Ballard et al. (2003); Lapinski et al. (2006).
$SC\text{-}M_8$	Prefabrication	Tam el al. (2007b); Jaillon et al. (2008); Silva and Vithana (2008).
$SC\text{-}M_9$	Waste management	Bossink and Brouwers (1996); CIB (1999); Kein et al. (1999); Kulatunga et al. (2006); Tam et al. (2007a); Tam et al. (2007b); Poon (2007); Jaillon et al. (2008).

Source: Bakhtiar et al. (2008)

Table 2.3 is a summary of developed methods for promoting SC. It is observed that most of the studies approached methods of promoting SC from various strategies that are underpinned by environmental sustainability agenda to promote economic performance. Comparatively, rhetoric on green building, green design, and green roof technologies are based on the delivery of constructed facilities with low carbon footprint. Strategies on prefabrication and lean construction are means of reducing materials demand during construction process to preserve the environmental. Even discourse on green procurement is centred on the environmental impacts of construction process. For instance, a study by Ngowi (1998) on procurement

practice in Botswana focused on environmental impacts of construction projects supply chain (raw materials, manufactured materials site operations, finished products and demolition).

Instinctively, the established methods for promoting sustainable construction practice validate the stance that, initially, theory of sustainable development is grounded on the needs for creating a balance between environmental protection and human developmental needs (Hill and Bowen, 1997). However, numbers of researchers (Whang and Kim, 2015; BS 8903:2010; Abidin and Pasquire, 2005; Du-Plessi, 2002) have expressed concerns and caution on the overzealous on environmental issues while evaluating SD. A discourse on SC upholds the stance that a knowledge gap exists in sustainable infrastructure as a method for promoting SC practice.

2.5: Sustainable Infrastructure

Infrastructures are constructed facilities, such as roads, ports, bridges, power plant, and water supply. They are set of services that underpin an effective functioning of a society. They also stimulate economic growth by facilitating manufacturing, services and trade. Inclusively, they contribute to social development through direct and indirect job creation.

There is no general acceptable definition for sustainable infrastructure (SI) in the literature. Nevertheless, it is generally accepted that the concept of SI emanates from the appraisal of infrastructure's environmental impacts in the late 1980's. Thome et al. (2016) gave the timeline of SI from green building to green infrastructure and from environmental sustainability to the triple bottom line of economic, social, and environmental sustainability.

For simplicity, infrastructures are considered being procured sustainably when the process meets the needs and promote value for money (Ashley et al., 2003; Dunmade, 2002; CIB, 1999; Ofori, 1998; Hill and Brown, 1997). Thome et al. (2016) observed that researches in SI are majorly focused on green infrastructure and sustainable building, and their assessment methods. Furthermore, methodological issues of cost-effectiveness are identified as one the emerging research themes in SI with discourse on the key subjects like integration of human, economic and corporate social responsibility values in environmental sustainability. These viewpoints have corroborated earlier stance of Arowosafe et al. (2015) on the evaluation of construction costs beyond tangible factors.

To date, SI delivery from a holistic contractors' pre-evaluation stance has not been well explored in DC. In most applications, sustainable procurement of infrastructure has been misconstrued for procuring constructed facilities from sustainable source and it describes the common interpretation of sustainable infrastructure in DC. Inter-American Development Bank (IDB, 2018) defined sustainable infrastructure as:

> *"the designing, building, and operating of these structural elements in ways that do not diminish the social, economic and ecological processes required to maintain human equity, diversity, and the functionality of natural systems"*

Literally, SI can be promoted at each phase of the project life cycle. However, decisions that are made at the pre-evaluation phase can greatly influence the success of SI as it applies to the management of human resources during construction phase.

Nevertheless, IDB (2018) argued that sustainable infrastructure cannot be achieved exclusively of social sustainability attributes. The delivery of SI is systemic in nature, though the scope of this study elaborates more on social implications of infrastructure delivery.

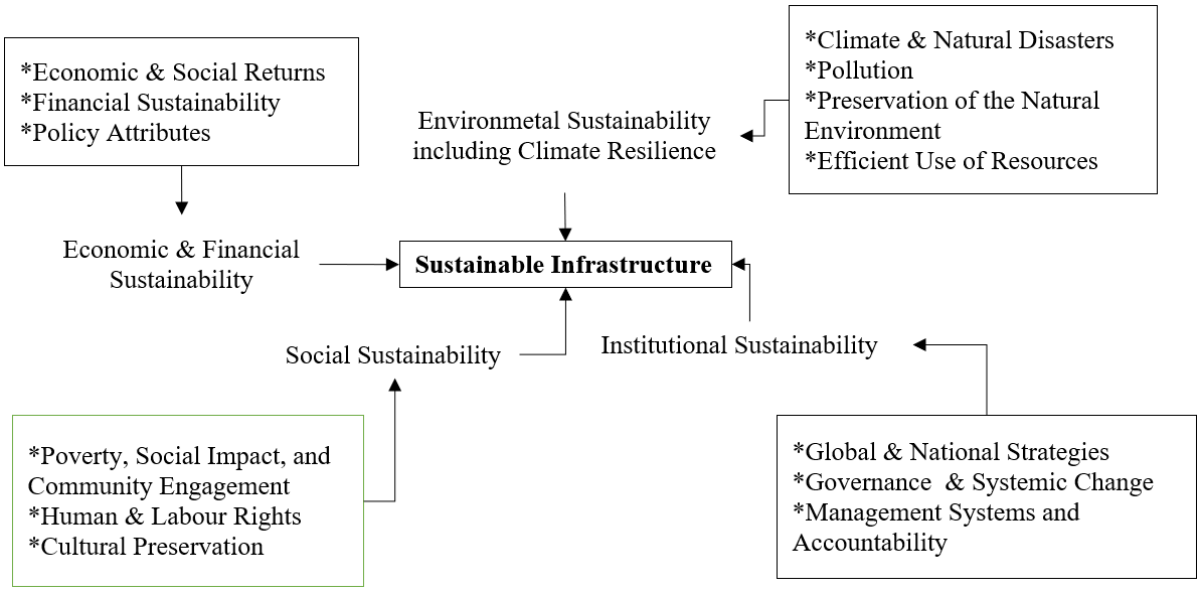

Figure 2-5 The four dimensions of infrastructure sustainability

Source: IDB (2018)

From figure 2.5, environmental dimension of sustainable infrastructure considers preservation, restoration, and integration of natural environment. Social dimensions pertain to response to the needs of the communities.

Social dimensions of sustainable infrastructure embrace poverty eradication, community engagement human right, and cultural preservation. One of the major challenges of Nigeria, as recognised by the global communities is poverty. Poverty is a global phenomenon with no generalised solution can be applied. Poverty is a condition of deprivation, which impedes human development (Omotola, 2008). However, drivers of poverty include non-empowerment, poor mental well-being, environmental degradation, economic insecurity and working condition (Ranis et al, 2006). In the context of sustainable infrastructure, engagement with the

community during infrastructure process is a demonstration of commitment towards empowerment and economic security.

Institutionally, sustainable infrastructure is the function of national and international policies and standards. It is the bedrock for the success of the other three dimensions of sustainable infrastructure. Robust institutional agenda uphold benchmark for best practice and local empowerment development. The institution develops a framework for the local capacity development, which include mechanism for of knowledge transfer, research and development.

2.6: Sustainability Rating System for Infrastructure Projects

Diaz-Sarachaga et al. (2017) identified three main rating systems that assess infrastructure projects from sustainability principles as ENVISION; Civil Engineering Environmental Quality (CEEQUAL); and Infrastructure Sustainability (IS). Like other methods developed to promote SC, it was found that three main rating systems for infrastructure projects gauge infrastructure economic performance and mitigation of environmental impacts

Recently, a recent research conducted by Diaz-Sarachaga et al. (2017) developed sustainable rating system for developing countries (simply SIRSDEC). It could be viewed as the landmark model for integrating social needs to infrastructure rating in DC. The decision-making tree for SIRSDEC is shown in Table 2.4.

Table 2-4 SIRSDEC decision-making tree

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Source: Diaz-Sarachaga et al. (2017)

SIRSDEC applied analytic hierarchy process (AHP) for decision problem structuring. The methodology of the AHP involves decomposing a decision problem to top-bottom structure (Saaty, 2013). The top level represents the main goal the process aims to achieve. In the middle layer are the criteria or attributes to achieve the goal. Depending on the complexity of the problem, sub-criteria may be included in this level. The bottom level is the alternatives, otherwise, various options that are available to be considered. The overall ranking of the alternatives against the evaluating criteria provides the best option for the decision problem.

The popularity of AHP among social researchers could be attributed to its problem solving through the measurement and interpretations of both tangible and intangible criteria (Whitaker (2007). Saaty (2013) argued that what is difficult to quantify in a real world, such as love, hate, peace, is far supersede those attributes that can be measured. Love, hate, peace cannot easily be gauged, yet their quantification provides good insight into the acceptance of a process.

Meanwhile, regardless of the popularity of the AHP, the rigid hierarchical structure of the problem has been criticised as less substantial for solving complex decision (Gencer and

Gurpinar (2007). Common assumptions that are often made during the implementation of AHP are as follow:

i. *Criteria are independent of one other*
ii. *Alternatives do not influence the importance of criteria*
iii. *Alternatives do not depend on each other (Saaty, 2013)*

Cheng and Li (2004) observed that most studies that applied AHP for the selection of contractor for construction projects assumed that criteria were independent of each other. Such assumption cannot hold in a real-life scenario, especially with the 'pluralistic' nature of construction clients in emerging methods for infrastructure procurement. Unlike traditional procurement strategy, the focal point is on stakeholders rather than project client under PPP strategy. In PPP, the usage of risk sharing reflects the relief of public client from their traditional responsibilities as stipulated under the traditional methods. This will necessitate a need for systemic approach during the evaluation of stakeholders' interests.

2.7: Barriers to Sustainable Construction in DC

Despite extensive studies being conducted on sustainable construction, no generalised barriers were found in the literature.

Table 2-5 Barriers to sustainable construction in DC

Barriers	Author (s)
Funding: Lack of funding, restrictions on expenditure and reluctance to incur higher capital cost when needed	Sourani and Sohail (2011); Du-Plessi (2002); Ofori (1999)
Knowledge: Lack of knowledge and awareness on the profitability of sustainable practice	Sourani and Sohail (2011); Du-Plessi (2002)
Management: Insufficient/inconsistent policies, regulations, incentives and commitment by leadership	Sourani and Sohail (2011); Sourani (2008); Du-Plessi (2002); CIB (1999); Ofori (1999)
Framework: Insufficient/confusing guidance, tools, demonstrations and best practice	Babatund and Low (2013); Sourani and Sohail (2011)
Definition: Vagueness of definitions and diversity of interpretations	Sourani and Sohail (2011)
Culture: Resistance to change. The concept of sustainability is new in construction sector and yet to be fully integrated as part of decision making and business practice	Sourani and Sohail (2011); Du-Plessi, (2002); Ofori (1999)
Research and Development: Insufficient research and development. It includes the reduction of the embodied amount of energy and materials of the products through research and innovation	Sourani and Sohail (2011); Du-Plessi (2002) CIB (1999)
Weak governance: Lack of legal and administrative systems for promotional activities, formulating and enforcing regulations	Oladinrin and Ho (2015); Du-Plessi (2007); Ofori (1999)
Lack of capacity of the construction sector	Du-Plessi (2002)
An uncertain economic environment	Du-Plessi (2007); Du-Plessi (2002)
Lack of accurate data	Du-Plessi (2002)
Poverty and low urban investment	Du-Plessi (2002)

Following extensive review of literature in built environment, identified barriers to SC are summarised in Table 2.5. The highlighted barriers further buttressed difficulties that are often associated with benchmarking for contractor selection in public domain.

2.8: Sustainable Infrastructure Delivery in Nigeria

The Nigerian Construction Industry has been identified as one of the fastest growing sectors in the world (NBS, 2015; Babatunde and Low, 2013; Ogunsemi and Jagboro, 2006). The sector represents the highest employer of labour in private sector (Ogunsemi and Aje, 2006). About 50% of the Nigerian government expenditures are budgeted on construction projects (Ogunsemi and Jagboro, 2006). Drivers to high demand of constructed facilities include high quantity of ageing infrastructure that requires replacement. Economic boost and growing population considerably add pressure to demand for constructed facilities (Sjostrom and Bakens, 1999).

However, due to contemporary issues (Ofori, 2011), local construction contractors (LCC) are unable to compete effectively in capital projects delivery for a time immemorial. Prior to Nigeria independence in 1960, indigenised foreign firms were the forerunner in construction industry in Nigeria (Adams, 1995). The capability of LCC in meeting national demand for civil and building projects is estimated at quarter of national building works and 5% of civil engineering works (Idoro, 2010; Adams, 1997). During the time, various policies were introduced by the government to promote capability building among local contractors, and they included:

i. *Work break down to suit the capability of individual contractors*
ii. *Provision of project supervisory staff by the government to support local contractor to resolve technical issues*
iii. *Reservation of some projects exclusively for local contractors*
iv. *Upfront payment of 10% contract sum as a mobilisation allowance.*

These measures were short lived due to shortage of funding from government to sustain technical assistance to contractors. The Nigerian ministries, department and agencies (MDAs), who are the major public clients (Ofori, 2011; Oluwakiyesi, 2011; Ebohon et al., 2002; Ngowi, 1998); Kaming et al., 1994), are prone to financial insolvency. This has resulted in the dearth of infrastructure projects. Lack of basic amenities, such as energy supply and good transportation system either impedes the capability of the local manufacturers to produce at a competitive price (Fernz et al., 2013) or they are forced to close for business (FGN. 2012; Taylor, 2007). This further poses a challenge on local sourcing of materials for construction activities.

Extant literature on construction industry in Nigeria discussed challenges of LCC (Oyedele et al., 2015 Babatunde and Low 2013; Oluwakiyesi, 2011; Adams, 1997; Kaming et al., 1994). They include shortage of skilled labour (Adams, 1995); poor funding (Adams, 1995); low mechanisation level (Idoro, 2012, Adams, 1995); low safety performance awareness (Idoro, 2008); quality performance (Oyedele, et al., 2015; Idoro, 2012; Idoro, 2010; Oyedele and Tham, 2005); lack of developmental strategy (Kaming et al., 1994); high construction cost (Ogunsemi and Jagboro, 2006); high construction cost (Ogunsemi and Jagboro, 2006); cost overrun (Oloyede and Tham (2007); abandonment of projects (Fernz et al., 2013); poor safety performance (Oyedele, et al., 2015; Idoro, 2012; Idoro, 2010, Idoro, 2008; Oyedele and Tham, 2005).

Over the past decades, structural failures and safety issues have resulted in building collapse in many parts of the country, resulting in the lost life and properties (Idoro, 2010). Coupled with concurrent disputes among contractors and government's ministries, department and agencies (MDAs), images of LCC have been severely damaged and the relation between ties of Governments had soared due to past experiences (Oyedele et al., 2015; Idoro, 2012; Ogunsemi and Jagboro, 2006).

Another noticeable issue is lack of coordinated long-term development plan (Enweremadu, 2013; Taylor, 2007) due to political instability. Not until fourth republic (1999-date), governance had been plunged with re-occurring topples of government by the military (Babatunde and Low, 2013; Enweremadu, 2013; Oluwakiyesi 2011).

Viewing from comparative advantages stance, multinational construction corporations (MCC) are more likely to be favoured with contract award in open competitive practice in Nigeria. Though, MCC are fewer in number, when compared with LCC, they remain a dominant figure in the construction sector due to capital and technical superiority. Idoro (2010) noted that over 90% of construction contract values in Nigeria are awarded to multinationals.

Though the importance of multinationals towards economic development in Nigeria is acknowledged, concerns are being raised on procurement being shifted towards privatisation (Du Plessis, 2007), Loxley, 2013). From capitalism theory, interests of the multinationals are more likely to lean towards exploitation (Enweremadu, 2013; Oyeranti et al., 2010; Taylor, 2007). Literature view on free economy system in Nigeria (Fernz et al., 2013) concluded that the practise of multinationals failed to promote social sustainability.

It is worrisome that construction market in Nigeria has been transformed to consuming dependent economies due to uncompetitive local sourcing. It implies that you must 'buy' if you cannot 'make' (Ikediashi and Okwuashi, 2015). Unless there is a review of the current trend in the perception of human needs in construction activities in Nigeria, the system will remain a consuming economy in perpetual.

To promote social sustainability in infrastructure delivery, government must strive towards creating enabling environment for economic activities. Ikediashi and Okwuashi (2015) identified key drivers of outsourcing in Nigeria, and they included cost related, strategy related, innovation related, quality related, time related and social factors. Economic factors play a decisive role on decision for outsourcing among leading MCC in Nigeria. This is evident in the practice of Chinese Civil Engineering Construction Company (CCECC). CCECC has emerged as the dominant firm in construction projects delivery in Nigeria. The mode of operation reflects their business strategy to exploits all economic and social benefits of the supply chain. CCECC business strategy includes global movement of almost entire construction workforces (skilled and unskilled) to execute construction projects (Taylor, 2007), with no regards to employment, human right labour law and regulations of host nations.

2.9: Economic Growth and Social Challenges in Nigeria

With the population of over 167 million in 2011 (FGN, 2012), Nigeria is considered as the most populous country in Africa. Vis-à-vis the economic growth, the country is also rated first in Africa and behind only China and India on global emerging markets (Enweremadu, 2013). The national GDP had reached $256 billion in 2012, in contrast to initial $46 billion in 2000. The improvement has been associated with improved global investors in key economic sector

Though Nigeria is considered to have a relative edge above many African countries in infrastructure development, dearth of constructed facilities is far from being resolved. An estimate of around $12b - $15b billion expenditure per year, over the next decade, is required to meet current infrastructure challenges (Opawole and Jagboro, 2016a). With an estimate of $10.5 billion needed for federal infrastructure alone, construction activities, therefore, have a great potential to support poverty eradication programme, considering prospective direct and indirect job creations.

Wistfully, socio challenges in Nigeria have remained almost consistent (Bukoye and Norrington, 2014; Ajufo, 2013; Enweremadu, 2013; Ebohon et al., 2002; FGN. 2012; Ofori, 2011 Oluwakiyesi, 2011; Idoro, 2010; Omotola 2008; Taylor, 2007). One of the toughest challenges confronting Nigeria is poverty. The nation is grouped among poorest countries in the world (Omotola, 2008).

Notwithstanding an average growth rate of 6.2% economy between 2002 and 2011 (Enweremadu, 2013; FRN, 2012), there are millions of populations languishing in extreme hunger and abject poverty (Ajufo, 2013; FGN, 2012; Omotola, 2008). Over 70% of the Nigerian population are estimated to live on a dollar ($) or less per day (NEEDS, 2008; Omotola, 2008). In modern economic system, a minimum wage is often introduced as an

earning to sustain an acceptable minimum living standard. This is a contrast in Nigeria, where a minimum wage is a mere feeding allowance as it fails to meet all the minimum requirements for living.

Unemployment level has risen from 3.8% in 2003 to 23.9% in 2012. Around 69.1% of the population are living below poverty level (FGN, 2012). The figures appear to be the most recent survey report of the National Statistics Bureau. In most recent report on poverty and equity in Nigeria (World Bank Group, 2019), the projected poverty percentage for 2018 was projected based on the international poverty line of $1.90 per person per day of 2011.

The class of people that are most affected are aged between 18 and 35 (Ajufo, 2013). This group constitute over 60% of the total population. Studies and reports on social development (Ajufo, 2013; FGN, 2012; and Omotola 2008) have closely associated poverty in Nigeria to high level of corruption and related social vices. The assertion is based on unprecedented kidnapping cases, robbery and established regional militant group. Though the viewpoint cannot be argued to be exclusive since not all entire population that is affect with poverty epidemics take to crime.

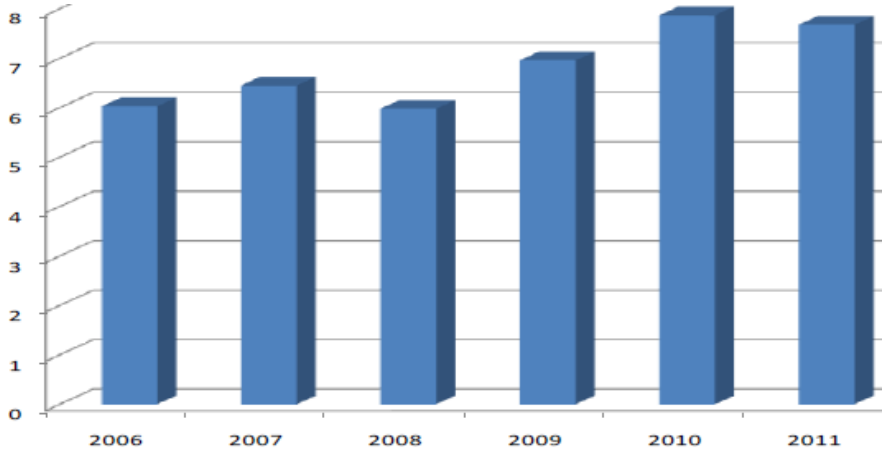

Figure 2-6: Growth Rate of Nigeria's GDP (%): 2006-2011

Source: FGN (2012)

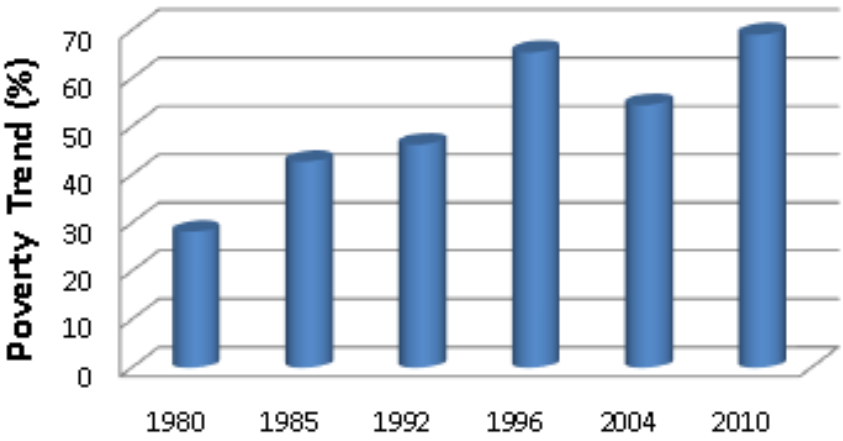

Figure 2-7: Relative poverty trends in Nigeria

Source: FGN (2012)

Figures 2.6 and 2.7 denote a contrast in GDP and poverty trend in Nigeria respectively. In fact, in many cases, economic growth has been misjudged as economic development. While the later focus on the wealth that is generated due to economic activities, economic development measure improvement on social wellbeing due to economic activities.

Numerous studies (Ajufo, 2013; Enweremadu, 2013; Lompo and Trani, 2013; Chukwuemeka et al., 2011; Otusanya, 2011; Omotola, 2008) have expressed concerns about the non-correlation between economic growth and social development in Nigeria. As highlighted in Agenda 21, eradication of poverty is a key measure for the success of national SD agenda.

2.10: National Economic Empowerment and Development Strategy (NEEDS)

The National Economic Empowerment and Development Strategy (NEEDS) is widely regarded as a poverty reduction strategy of the fourth republic in response to the development challenges of Nigeria (NEEDS, 2008; Okonjo-Iweala and Osafo-Kwaako, 2007) Prior 1999, Nigeria was subjected to military rule, and characterised with lack of good leaders, corruption, and lack of funding, lack of personal values, environment that is not conducive for economic growth, and lack of monitoring and evaluation mechanism to gauge sustainability performance and poor attitude to research and development (Bukoye and Norrington (2014).

NEEDS had signalled government's plan towards creating a quality of life for her citizens and objectives of partnership with international community (IMF. 2005). The four blueprints of NEEDS were: wealth creation, employment generation, poverty reduction, and value reorientation (NEEDS, 2008; Omotola, 2008; Okonjo-Iweala and Osafo-Kwaako, 2007).

NEEDS agenda highlights the important role of private sector development towards wealth creation and poverty reduction in Nigeria. Overall, the objectives of NEEDS could be summarised to four key areas: macroeconomic reform, structural reform, public sector reform, institutional and governance reform (Okonjo-Iweala and Osafo-Kwaako, 2007).

2.11: The Nigerian Public Procurement Act of 2007

The Nigerian government budgetary for infrastructure is extremely dependent on crude oil earnings. A plunge in the Nigeria oil market always has multiplier effects of foreign earnings and subsequent distortion to the economy. As a result of plunge in the Nigerian oil market in the early 1980s, being a major source of foreign earning, there was huge distortions in economy. To secure loan from the World Bank towards capital projects, a Country Procurement Assessment (CPAR) was mandatory by the world financial authority as a prerequisite of lending terms (NCPAR, 2000).

The CPAR field work was jointly conducted by local and foreign consultants. The local consultant provided the required local knowledge for a successful completion of the questionnaire. The foreign consultant completed the report with the international perspective and experience. The primary objectives of the CPAR were to:

1) *review the country's public sector procurement structure, including the existing legal framework, organizational responsibilities and capabilities, and present procedures and practices, including how these may differ from the formal rules and procedures*
2) *make possible a general assessment of the institutional, organizational and other risks associated with the procurement process.*
3) *establish the basis for dialogue between the country and donors on how to streamline and improve the economy, efficiency and transparency of public sector procurement.*
4) *develop a detailed action plan for reform to achieve institutional improvements, including interim modifications to existing practices in the country so that contracts being financed under current projects will meet the Bank's procurement standards pending completion of the broader reform program; and encourage better commercial practices in the private sector* (NCPAR, 2000)

The findings of the CPAR report revealed irregularities in public procurement. Public projects delivery was characterised with inflation of contract cost, lack of adequate plan, poor project prioritisation, and lack of competition. it was concluded that poor performance in public procurement were due to:

1) *Absence of a public procurement law*
2) *No institution with the responsibility for issuing policy direction on public procurement*
3) *No defined standards for conducting procurement*

Nevertheless, all the findings leaned towards lack of an effective and an efficient framework for enhanced economic performance. This clearly reflects the scope of CPAR. It could be noted that the primary objectives of the CPAR included risks that were associated with the procurement process, neither social nor environmental risks were evaluated during the assessment.

Following the recommendation of CPAR for the establishment of a legal framework and procurement policy, the Public Procurement Act (PPA) was enacted in 2007 (NCPAR, 2000). The Nigerian Bureau of Public Procurement (BPP) was formulated under PPA act and it served as a regulatory authority for public procurement in Nigeria (NCPAR, 2000).

Table 2-6: Basic procurement system requirements

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Source: BS ISO 10845-1:2010

The principal hallmarks of proficient public procurement by BPP are replica of the key principle of public procurement system that are applicable in the United Kingdom (see Table 2.6). It could be attributed to Nigeria being a former British colony. This is a noticeable another aspect of developmental challenges in developing countries. It is quite often countries to adopt

measures that have not been able to be adapted owning to inadequate or absence of critical institutions.

2.11.1: Efficiency and Effectiveness

Efficiency and effectiveness relate to inputs and outputs of procurement process. BPP consider public procurement as being efficient when it is swift in producing positive result. According to DFID (2011), efficiency measures how well inputs are converted to outputs. Effectiveness is more contextual, and it measures how outputs of procurement process respond to key project objectives.

2.11.2: Competition

Competitive tendering is commonly used by public client to procure goods and services. In developed nations, competition is mandated to promote VfM (Brammer and Walker, 2011). A project package is first developed and invitation to tender is made through advertisement. The accepted bids are evaluated by the procurement team based on project-based performance criteria. Open competitive system is the preference of finance institution such as the World Bank due to its fairness and equal opportunity to potential contractors to deliver project at the lowest cost.

2.11.3: Transparency

Transparency in procurement demonstrates openness and creates enabling environment for competition to strive (Bukoye and Norrington, 2014). Transparency also implies that procurement process must be dislodge of any form of ambiguity. For instance, government agencies must specify clearly the intended criteria for the award of contract (such as price, functionality, life cycle costs, services contracts, prequalification, and experience), which must apply to all prospective bidders.

2.11.4: Ethics

Ethical consideration in procurement relates to moral and professional conducts of personnel that are entrusted with procurement process (Moodley et al, 2008; Wiredu, 2005). It is the responsibility of procurement personnel to demonstrate prominent level of ethical conduct at all time (Raymond, 2008). Corruption is a very critical ethical issue in public procurement, and the act is more prevalent in DC.

A review of BPP in Nigeria revealed lack of clarity on procurement ethics. Another ethical issue inconspicuous is social value. The concept of VfM revolves mainly on construction cost reduction no clear definition of contractor's social obligation and mechanism for the impletion of the enforcement of 'local content' in public infrastructure delivery.

Though, elements of social value are not inclusive in the basic procurement system requirements (BS ISO 10845-1:2010), which guided the formation BPP in Nigeria. However, UK's Social Value act of 2012 and EU public procurement directives of 2014 provide guidelines for the basic requirement for social sustainability in sustainable public procurement.

2.11.5: Accountability

Accountability is very crucial in public sector (Raymond, 2008). Best practice requires that procurement officers practice openness and liable for the consequences of their action (Bukoye and Norrington, 2014). In general, the principal hallmarks of proficient public procurement are not independent of one another. Abuse of one principle invalidates the entire procurement process. For instance, the degree of competition and transparency demonstrate how accountable a public procurement is (Brammer and walker (2011).

2.12: Infrastructure Concession Regulatory Commission

The Nigerian government considered PPP procurement strategy as a timely solution to the dearth of infrastructure projects which hampers economic development. The goal of government strategy for sustainable infrastructure delivery was to collaborate with the private sector in the procurement of public infrastructure (ICRC, 2012). The Federal Government of Nigeria established Infrastructure Concession Regulatory Commission (ICRC) in 2008, under Infrastructure Concession Regulatory Commission (ICRC) Act of 2005. The key role of ICRC was to create a sustainable environment for the participation of private sector in infrastructure delivery (ICRC, 2012).

In Nigerian context of PPP, public sector embraces all tiers of government and MDAs. Private sector is part of the national economy but is owned, controlled and managed by private individual or companies.

Meanwhile, the usage of the terminology in the existing literature has generated debate on the best meaning for multinationals corporations (see Table 2.7).

Table 2-7: Definitions of Multi-nationality by Previous Researchers

Source: Beldona (2000)

Despite comprehensive worldviews on MNC, it is observed that there is no unified definition among scholars (see Table 2.7). This has given rise to terms such as Multi-nationality, Transnational and International Corporation in various literatures. Financial support and technology transfer have been identified as a one of the dominance factors of MNC in DC (Osabutey *et al.,* 2013). The practice of MNC commonly allow for free movement of capital and resources across borders and in most cases host nations are marginalised and exploited due to dominance of multinationals in the formulation of economic policy. The absolute economic interests of the multinationals are further evident with different strategies and machineries that are used to either to evade or avoid tax payment in Nigeria (Otusanya, 2011). This further re-ignites contentious arguments over decades in the literature on international political economy on roles of the multinational enterprises in the third world (Chukwuemeka *et al*., 2011). OCED, (2011), among others, disclose that transnational corporations are habitually economic inclined and take the opportunities of weaknesses of the host nation, and therefore, they may pose external threats to economic development.

Kindleberger, (1969), *cited* in Annavarjula and Beldona, (2000), contended that for an enterprise to be certified as international corporation, equity is vital in operation system and this can only be accomplished through the elimination of appellation: 'home and host nation', which are common feature in the depiction of multinationals. Study by Idoro (2010), on patronage of LCC and MCC in Nigeria, reflected that 90% of total value of infrastructure projects were awarded to MCC. It is therefore argued in this study that PPP in Nigeria is MCC in disguise.

With the scope of PPP spanning to across transportation, power projects, telecommunication, water supply, solid waste management, housing, education, agriculture, and health facilities, it buttresses the significance of sustainable infrastructure on virtually all sectors of the economy.

ICRC is responsible to regulate, monitor, and supervise PPP projects. The commission is also responsible for setting standards that facilitate the implementation of PPP with VfM agenda. The key principles of PPP were guided by the best practice in procurement as proscribed by the Nigerian Bureau of Public Procurement.

2.13: Contractor Selection Process for Infrastructure Procurement in Nigeria

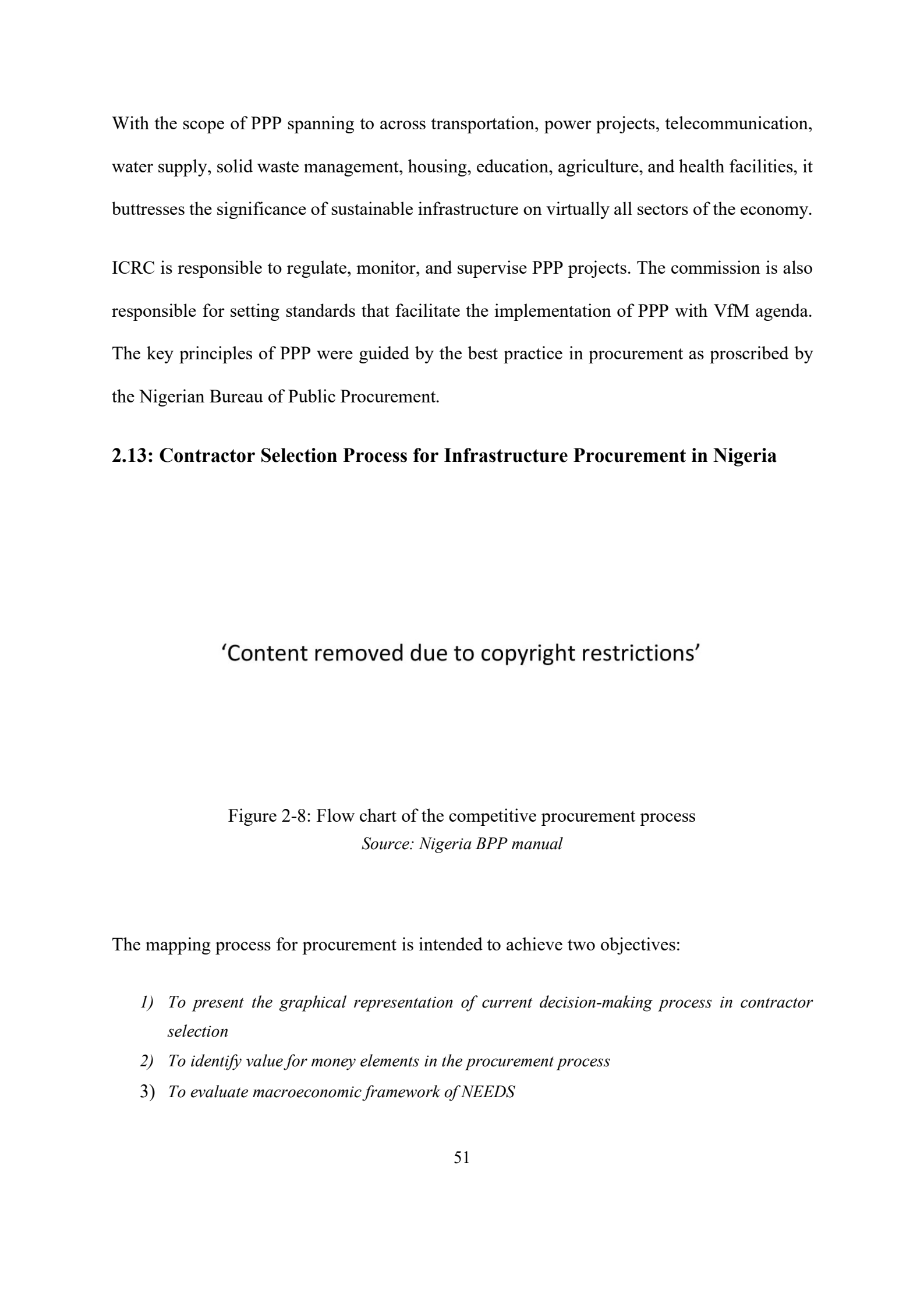

Figure 2-8: Flow chart of the competitive procurement process
Source: Nigeria BPP manual

The mapping process for procurement is intended to achieve two objectives:

1) *To present the graphical representation of current decision-making process in contractor selection*
2) *To identify value for money elements in the procurement process*
3) *To evaluate macroeconomic framework of NEEDS*

From the flow chart that is applied to infrastructure procurement, the usage of 'need' in the procurement process is exclusively a tangible term. A need simply defines infrastructure that requires a maintenance or replacement. Two principal methods of selection are Invitation for Bids (IFB) Requests for Proposals (RFPs) They are procedures for generating competing offer from pool of contractors looking to obtain an award of construction works, supply or service contracts. On pre-evaluation criteria of contractors, BPP emphasised majorly on the reputation and integrity of prospective contractors. General conditions for disqualification of contractors are summarised as follow:

1) *Bribery*
2) *Poor past performance*
3) *Weak financial capability*
4) *Tax fraudulence records*
5) *Past conviction*
6) *Bad public image*
7) *False declaration*

Contractors' strategies for social sustainability are not pronounced in the requirements. The current procurement process has failed to implement key strategies for socio-economic development as defined in NEEDS, which include collaboration with private sector and empowerment.

2.13.1: Structural Adjustment Programme and The Nigerian Local Content Bill

Prior Structural Adjustment Programme (SAP) era in Nigeria, the Nigeria economy was actively controlled and regulated by the government. The goal was to promote social sustainability through inclusion of locals in economic activities in key economic sectors. The oil boom era of 1970s boosted financial capability of the government and further strengthened the growth of the state-owned enterprises and local companies to flourish under the

governments' nationalisation agenda. Laws were enacted to foster the growth of the local companies and capacity building among the locals, which demonstrate true economic independence (Ekhator and Anyiwe, 2016). Notable law enacted was the Immigration Act 1963. According to Section 8(1) (b) of the Act:

> *"....no person other than a citizen of Nigeria shall on his own account or in partnership with any other person, practise a profession or establish or take over any company with limited liability for any such purpose without the consent of the minister"* (Ekhator and Anyiwe, 2016).

The vision for national wealth creation further led to the promulgation of various decrees that included Nigerian Enterprises Promotion Decree 1972 and the Nigerian Enterprises Promotion Decree of 1977. The goal of the reformed economic agenda was not an absolute restriction on international trade, rather to sustain social development through better empowerment of the local people. To achieve the target, multinationals were controlled in the financial, managerial and technological dominance of the key economic activities (Ekhator and Anyiwe, 2016).

The collapse of the Nigeria economies in the 1980s was grossly linked to excessive involvement of government in service delivery and shortage of revenue due fall in oil price (primary source of national income). By 1983, Nigeria's shot term trade arrears was already over N4 billion (Anyanwu, 1992). Due to shortage of funds to provide basic services and reactive measure to prevent further economic decline, the Nigerian government sought for loan from the Britton Woos Institutions (World Bank and International Monetary Fund (IMF)) in 1980's (Anyanwu, 1992).

SAP is a market-oriented reform policy initiated by the Britton Woos Institutions aimed at restructuring and diversification of national economy. SAPs in Nigeria almost the same policy in African nations at large. It is assumed that DC are experiencing similar developmental problems. The policy is created to allow the economy to be more market oriented. Key terms and condition for loan grants to DC by the Britton Woos Institutions included privatisation and deregulation (Anyanwu, 1992).

Since the implementation of SAP policy in Nigeria, there has been a periodic devaluation of currency and high inflation. Within 1986 -1989 alone, inflation had risen from 5.4% to 40.9% respectively (Anyanwu, 1992). Consequently, indigenous are neither capable of building farms nor set up manufacturing companies. The country has been transformed to consuming economy (Ofori, 2001), relying on the consumption of finished imported goods. Job creation is adversely hindered. This is because for every tonnes of imported goods, the opportunity costs include deprivation of local job creation and decline of local industry.

The enactment of the Local Act of 2010 in Nigerian could be attributed to the failure of SAP, as notable in declining local capacity building despite growing economy (Ayomike and Okeke, 2015). The philosophy of the modern Nigerian Local Content (NLC) is to achieve a value-added economy through development of indigenous capability through their integration into key economic sectors (Fernz et al., 2013). According to Industrial Participation Policy Act 2011,

> *"Local content refers to goods, services and labour provided by businesses located in proximity to the project site… and can be extended to include adjoining regions, the whole of the State, other States and Territories"* (Fernz et al., 2013)

Though, at the inception, LCB focused on oil and gas industries (Fernz et al., 2013), the success has been emulated in construction industry, being another key economic sector (Babatunde and Low, 2013). Meanwhile, a review of the LCB for the Nigerian construction industry (Fernz et al., 2013) had not been successful due to identified setbacks:

1) *Definition of value added for enterprises, workers and materials suppliers are inconclusive*
2) *No clear objectives that comprehensively prescribe the increased participation of the Nigerian people in the construction industry*
3) *Lack of clear and practical definitions what constitutes a Nigerian firm*
4) *The bill was initially based on the Oil and Gas Industry Nigerian Content Act and therefore does not reflect the characteristics of the construction industry*
5) *It does not include quantifiable targets for Nigerian content. The Nigerian Content Construction Industry Monitoring Board (NCCIMB) is expected to set these targets*
6) *The requirement for the proposed NCCIMB to approve a local content plan for every single construction project is impractical, particularly as it covers both the public and private sector*
7) *The proposed requirement for training and capacity building based on a test of reasonable effort is weak*
8) *Public procurement officials are likely to be concerned with the potential conflicts between the Bill and the requirements of the Public Procurement Act 2007.*
9) *There is an absence of data to be able to quantify potential impacts on employment generation and income improvement.*

Despites of the opportunities and good intent of the LCB in construction, questions are still raised on the maturity and capability of the local firms to deliver value. Considering the prospects of multinationals, if well-coordinated, Babatunde and Low (2013) believe that strategic and sustainable joint venture between expatriates and local firms remain a solution to unlock values of construction delivery.

2.14: Private Construction Contractors in Nigeria

Private' in Public Private Partnership (PPP) can be viewed as all business entity that is not publicly owned. Generally multinational corporations and indigenous privately-owned companies can be assumed as private entities. In this study the classification of private entity in PPP is contextual to the loyalty of multinationals. In this study, private sector in construction sector of the economy is simplified as Local Construction Corporations (LCC) and Multinational Construction Corporations (MCC). One of the burning issues that remains unresolved is the definition and understanding of the constituent(s) of 'Private' in Public Private Partnership (PPP). The definition of 'private' in contractual agreement will go a long way to determining the extent that sustainable infrastructure development can contribute to economic growth and development.

Aharoni (1971), cited in Beldona (2000) defined a multinational one that controls a group of corporations, each created in the country of operation, but all controlled by one headquarters. Rolfe (1970), cited in Beldona (2000) defined multinationals as a company with a proportion of foreign sales, investment, production, or employment of at least 25 percent. Kindleberger (1969), cited in Beldona (2000) defined multinationals has no country to which it owes more loyalty than any other, nor any country where it feels completely at home. It equalizes the returns on its invested capital in every country, after adjustment for risk.

The practice of the multinationals in the Nigerian construction industry is not a brand-new phenomenon. It was dated back to decades before independence era when the nation was under the colony of British Empire. In 1932, Cappa and D'Alberto were established as the pioneer foreign construction in Nigeria (Idoro, 2010). To date, the influx of MCC has soared and more foreign investors are actively competing for construction projects. CCECC, for instance has

been transformed to a leading multinational in infrastructure delivery in Nigeria (Taylor, 2007). Meanwhile, CCECC ideology in Nigeria reflect partial loyalty business strategy to host nation (Taylor, 2007).

Though practice of private entity in the Nigerian construction industry could be traced to 1932, when Cappa and d'Alberto was established (Idoro, 2010), the chronicle of the modern multinational practice in construction sector was influenced by globalisation and trade liberation (Lewis, 2007).

The over-dependence on foreign construction capacity is now a new practice in Nigeria (Adams, 1995). The new trend, however, is the emergence of Chinese Civil Engineering Construction Company (CCECC) as the key player in infrastructure delivery (Babatunde and Low, 2013). Though, Ayodele and Sotola (2014) and Nabine (2009) noted that interests of Chinese government in Nigeria economy to be dated as far back as 1950s, Nigeria-China partnership has been solidified by the Nigerian government economy reform policy of the 'fourth republic' (1999 to date), which highlights the Nigeria's post military rule. The Nigeria's *'look east policy'* (Ayodele and Sotola, 2014; Babatunde and Low, 2013), at the beginning of new millennium, had strengthened bilateral trade agreement with China.

Chinese Civil Engineering Construction Company (CCECC) has emerged as the dominant firm in construction projects delivery in Nigeria. CCECC are being acknowledged as the largest and most competitive construction firm in the world (Ayodele and Sotola, 2014; Babatunde and Low, 2013). As a frequent practice, technologically and economically advanced nations give aids to recipient country to foster their economic and political ambitions. With vast opportunities of resources and construction projects in Nigeria, Chinese government ensured that Nigeria enjoyed largest portion (20.2%) of Chinese foreign direct investment (FDI) flows

to Africa (Babatunde and Low, 2013). CCECC engage in virtually all construction activities (power plants, railways, bridges, dams, sport facilities, hospitals, schools and housing) in Nigeria.

While the practice 'go-global' construction is underpinned with private funding for infrastructure delivery, sustainability of government alliance with CCECC has attracted interest and scrutiny from number of scholars (Ayodele and Sotola, 2014; Oyeranti et al., 2010; Morrison, 2009; Nabine, 2009; Taylor, 2007). Findings by Oyeranti et al. (2010) and Taylor (2007) reflected purely economic interests of foreign aids initiatives. The trend has significantly promoted new ethnic concept. Chinese firms are notable to overturn 'local content' with their economic policy (Taylor, 2007). Their mode of operations has little or no deference to socio-procurement, safety standards, human right labour law compromised law and regulations of host nations. To meet demand of their growing population, Chinese firms ensure those almost entire workforces (skilled and unskilled) are moved around the globe to execute their construction projects (Taylor, 2007).

In addition to fundamental contract terms, China often practice 'trade by barter' with DC countries like Nigeria in exchange for their services of infrastructure delivery for natural resources (Babatunde and Low, 2013). Example is the allocation of four oil exploration licences to China in 2006 for investment in infrastructure that was estimated for $4billion. Under the 'trade by barter' terms, Chinese firms take absolute control of construction value management, with absolute freedom for outsourcing of materials and human resources. The practice constitutes capacity development and growth of local industries Furthermore, the grant of the *'right of first refusal'* to CCECC by the Nigerian government (Taylor, 2007) summarises lack of transparency, economic and political privileges that are accorded to Chinese firms in

Nigeria. In the ranking of corrupt country by the transparency International's Corruption Perception Index, Nigeria is ranked as the 42nd most corrupt country out of sample 183 countries (Bukoye and Norrington, 2014). Greater percentage of the non-transparent contracts in infrstructure and construction related projects in Nigeria involved leading MCC. The mode of contract formation for infrastructure projects by MDAs is a barrier to best VfM doctrine because it is debugged of transparency and ethical considerations (Bukoye and Norrington, 2014; DFID, 2011).

Yet, in the recent economic report, Nigeria is rated as the world leading trading partner with Chinese (Taylor 2007). She is also the first country in Africa to sign a Memorandum of Understanding with China on the establishment of Strategic Partnership (Taylor 2007). Infrastructure deal in Nigeria is an integral part of China's business strategy in emerging economies (Taylor, 2007). Chinese government is attracted to specialised sectors of the Nigeria economy that include construction, oil, telecommunications, and pharmaceutical fields (Taylor, 2007). Taylor (2007) noted that policy makers in various parastatals and agenciers in Nigeria are yet to evaluate implications of partnership in a broader scope. Debate on the impacts of CCECC to the socio development in Nigeria and DC at large will linger on until standardised criteria for value evaluation is developed and reviewd overtime.

Nevertheless, Nigeria; requires support of private sector to strive in economic growth and development, as highlighted in MDGs (Nigeria MDGs, 2010; Du Plessis, 2007). This further supported by views of Ayodele and Sotola (2014) on the pursuit of Chinese investors by the government, contrary to opinions that they imposed them.

The classification a corporation as local private sector or international private sector can, therefore, be based on culture and loyalty. Hofstede (1994a), cited in Pryke (2009) defines culture as;

> *"the collective programming of the mind which distinguishes one category of people from another"*

Culture encompasses what is done, how things are done, why things are done, when things were done and by whom things were done. These key notes underpinned general classification of private organisations.

Though CCECC in Nigeria can be classified as a multinational private sector, Ayodele and Sotola (2014) commended the loyalty of CCECC to take unusual construction and business risks that are commonly avoided by the 'western' competitive construction corporations. MCC from the '*east*' are more passionate than the *'west*' that introduced various economic and political liberation measures e.g., SAP, as debt control and financial support pre-requisites. This is evident in the granting of estimated $1.3 billion debt cancellation to 31 African countries in 2000 (Ayodele and Sotola, 2014).

2.15: Summary

This chapter reviewed the links between sustainable infrastructure project development and contractors' selection practices in Nigeria. This is very important to achieve social sustainability in infrastructure project. To understand this, there was a brief review on how sustainable development was understood and A21 SCDC. Sustainable infrastructure delivery was also located within the framework of A21 SCDC

One of the key issues in sustainable infrastructure project development in Nigeria is the lack of policy, which integrate and enforce social sustainability to contractors' selection process to capital project delivery. This has limited the benefits that is gained from construction activities to physical structure delivery.

CHAPTER 3 : MAJOR CONSTRUCTION PROCUREMENT METHODS USED FOR CAPITAL PROJECTS

3.0: Introduction

The purpose of this chapter is to review and discuss the general characteristics of the major procurement methods used for capital projects to justify the most sustainable method for procuring public infrastructure in Nigeria. This chapter starts with the general overview of sustainable construction procurement. This chapter elaborates on the streams of PPP, being the key procurement strategy that underpins this study.

3.1: Sustainable Construction Procurement

Procurement is a broader concept for promoting sustainable construction practice, but it is often limited to environmental sustainability in the literature. There is no consensus definition for sustainable procurement as it reflects in differential procurement practices among countries (Islam et al., 2017). Meanwhile, there are theoretical views that can assist individual organisation and nation to model their sustainable procurement principles (BS: 8903:2010; Du-Plessi, 2007).

Over the years, the understanding and interpretation of sustainable procurement has evolved. At the conception, focus sustainable construction procurement was on the use of energy and reduction of environmental impacts. This was later elaborated to include technical issues in construction, which include construction technologies, building materials and components. The new trend now embraces non-technical issues, otherwise termed ‘soft’ issues (EU Directive 2004/18). This is related to the interaction between economic activities and society during public infrastructure delivery. Soft issues are best illustrated from social construct. They are not easily quantifiable as they deal with subjective views and feelings. Non-technical issues on

sustainable development in the content of this study include sourcing of material and human resources for construction supply chain management.

Islam et al. (2017) identified five dimensions of sustainable procurement to include environmental management, diversity, working condition and human rights, safety, and engagement with the community. Despite the plethora of studies on sustainable construction procurement, scope and agenda are always centred on environmental procurement, with extensive studies on the implication of materials application and energy consumption in construction process.

With the vast of research undertaken in sustainable construction procurement over the past decades, not a single reference has been made on social procurement (Loosemore, 2016). Loosemore (2016) viewed social procurement in construction projects as the use of procurement to derive additional social benefits and create social value in local communities beyond the fundamental purchase of goods and services. The concept validates Porter's 'diamond model' (Porter, 1990) for the creation and sustenance of national competitive advantage through a highly localised process. Example is the delivery of project values beyond mere physical infrastructure but with responsive mechanism for employment creation for the locals without discrimination. The USA has a long-time legal requirement for the inclusion of social procurement strategies by the tenderers for public infrastructure. Legislations, such as UK's Social Value act of 2012 and EU public procurement directives of 2014 are enacted (Loosemore, 2016). They constitute legal requirements for the clients of publicly funded projects and the tenderers to consider wider economic, social and environmental impacts of their procurement decisions. It also encourages the inclusion of the community in the evaluation of their expected social values from the constructed projects. The development

signifies the commitment of the UK and EU in general to social procurement in public infrastructure procurement.

3.2: Benchmarking in Public Infrastructure Procurement

Per Anderson and Patterson, cited in Palaneeswaran and Kumaraswamy (2000), benchmarking is *"the process of continuously measuring and comparing one's business processes against comparable processes in 'leading' organizations, to obtain information that will help the observing organization to identify and implement improvements"*. Palaneeswaran and Kumaraswamy (2000) categorised benchmarking exercises into two categorises; what is compared (e.g., performance, process and strategic) and whom it is compared against (e.g. internal, competitive, functional and generic). Raymond (2008) viewed benchmarking and performance measurement as the main techniques that are frequently used to improve public organisation. While benchmarking allows for general weighing of performance in comparison to other practices, performance measurement is more contextual. Performance measurement involves collection, analysing and reporting information regarding the performance of an individual organisation or a system.

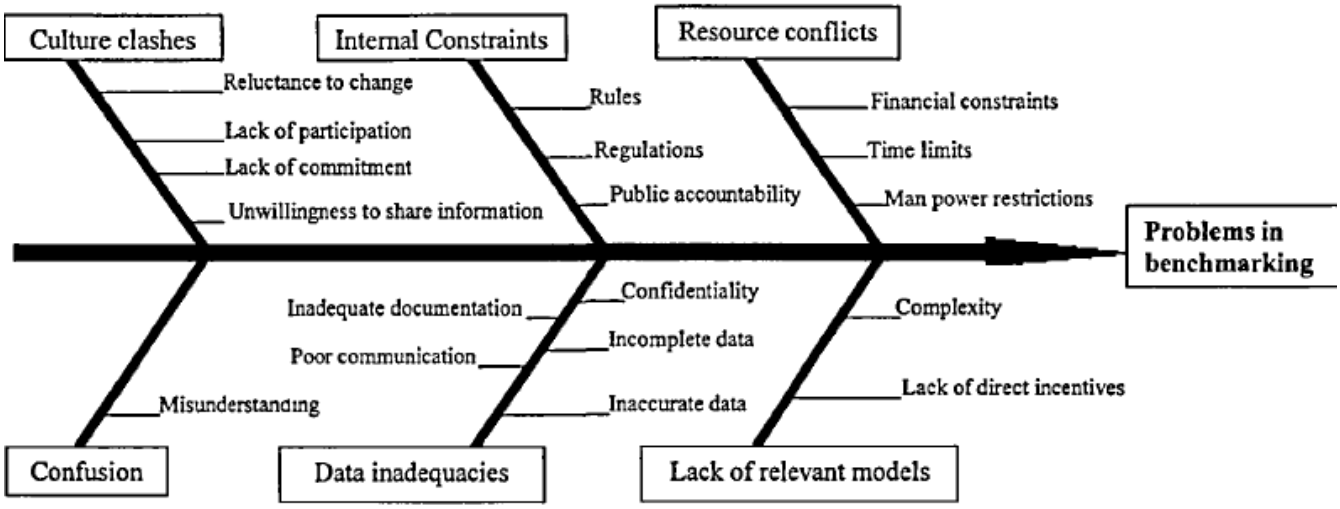

Figure 3-1 Cause-and-effect diagram for public sector benchmarking problems
Source: Palaneeswaran and Kumaraswamy (2000)

As highlighted in Figure 3.1, benchmarking for public sector presents a mammoth task. The dynamism of the modern procurement strategies requests for a systemic appraisal of stakeholders' perceived performance measurement to derive objective VfM.

Ambiguity in the definition of VfM constitutes confusion in the formation of sustainable requirements for public procurement. Due to limited information about social value in contract formation, the application of the traditional contractors' selection criteria is still prominent in modern procurement strategies.

3.3: Ethical Issues in Construction Industry

Ethics is the philosophical study of what is right and wrong in human conduct and the appropriate principles that should govern it (Moodley et al., 2008; Wiredu, 2005). Ethics pose huge problem in construction management due to the construction stakeholders spanning across national borders, they are politically, socially, culturally and economically divided (Moodley et al., 2008). Therefore, adapting ethical approach devised in developed countries to developing countries may not yield expected values due to differential needs and challenges (Wiredu, 2005). This poses huge challenges on ethic, which are a set moral principles or forms of conducts that is most suitable in construction procurement.

Wiredu (2005) made further clarity on global ethics from an ethic perspective, which is the contextualised way of regulating behaviour by individual society. Though global ethic may not necessarily be a substitute for local ethic (Wiredu, 2005), it is a good basis to review worldview from entire new perspective to gain knowledge of best practice. A study by Oladinrin and Ho (2015) was more insightful on ethical issues in construction industry, with emphasis on bribery, abuse of resources, favouritism, discrimination and harassment. Based on critical review of

several guidelines and codes of conduct for ethical conduct, (Moodley et al. (2008) have identified generalised ethical issues in global context in Table 3.1.

Table 3-1 Global ethical issues

Accountability	**-Governance-Transparency-Disclosure-Ethical leadership**
Conduct	-Compliance with laws-Corrupt Practice-Anti-competitive practice -Political Lobbying-Buying Influence-Whistle Blowing-Integrity
Supply chain	-Skills assessment-Integrity-Cross-cultural issues-CSR
Labour and human rights	-Freedom of association and collective bargaining -Elimination of forced and compulsory labour -Abolition of child labour -Elimination of discrimination in the workplace -Collusion with security forces
Health and safety	-Compliance with laws-Duty of care-Global health and safety codes -Local practice and customs
Community	-Charity-Local Causes-Employment-Damage to environment
Environment	-Compliance with codes-Carbon Footprint-Pollution-Waste -Use of water-Habitat Destruction-Impact on biodiversity safety
Customers and products	-Ergonomics-Recyclables-Duty of care-Transparency

Source: Moodley et al. (2008)

Construction industry is rated as most unethical economic sector globally. The problem is more severe in DC where the system is characterised by low skill level, poverty, weak governance, low level of research and development (Oladinrin and Ho, 2015; Du-Plessi, 2007; Ofori, 1999). Ethical issue, therefore, remains one of the key barriers to sustainable infrastructure delivery in developing and developed countries generally.

4.2: Value for Money

Perry (1914) posed a question on what value is, in general by rehearsing the contemporary argument that value cannot be defined. Francis et al., (2014) noted further that contributory factors to ambiguity in value studies included large variety of linguistic usages of the term, with ‘value' being used as a verb, adjective and noun. It was further stressed that it would be impossible to effectively study something that is inadequately defined. Lee and Barrett (2006) summed up two approaches to value study as ethical stance and monetary terms.

According to British Standard (BS-EN 12973:2000), value is not absolute but relative. It is the relationship between the satisfaction of need and the resources used in achievement that satisfaction.

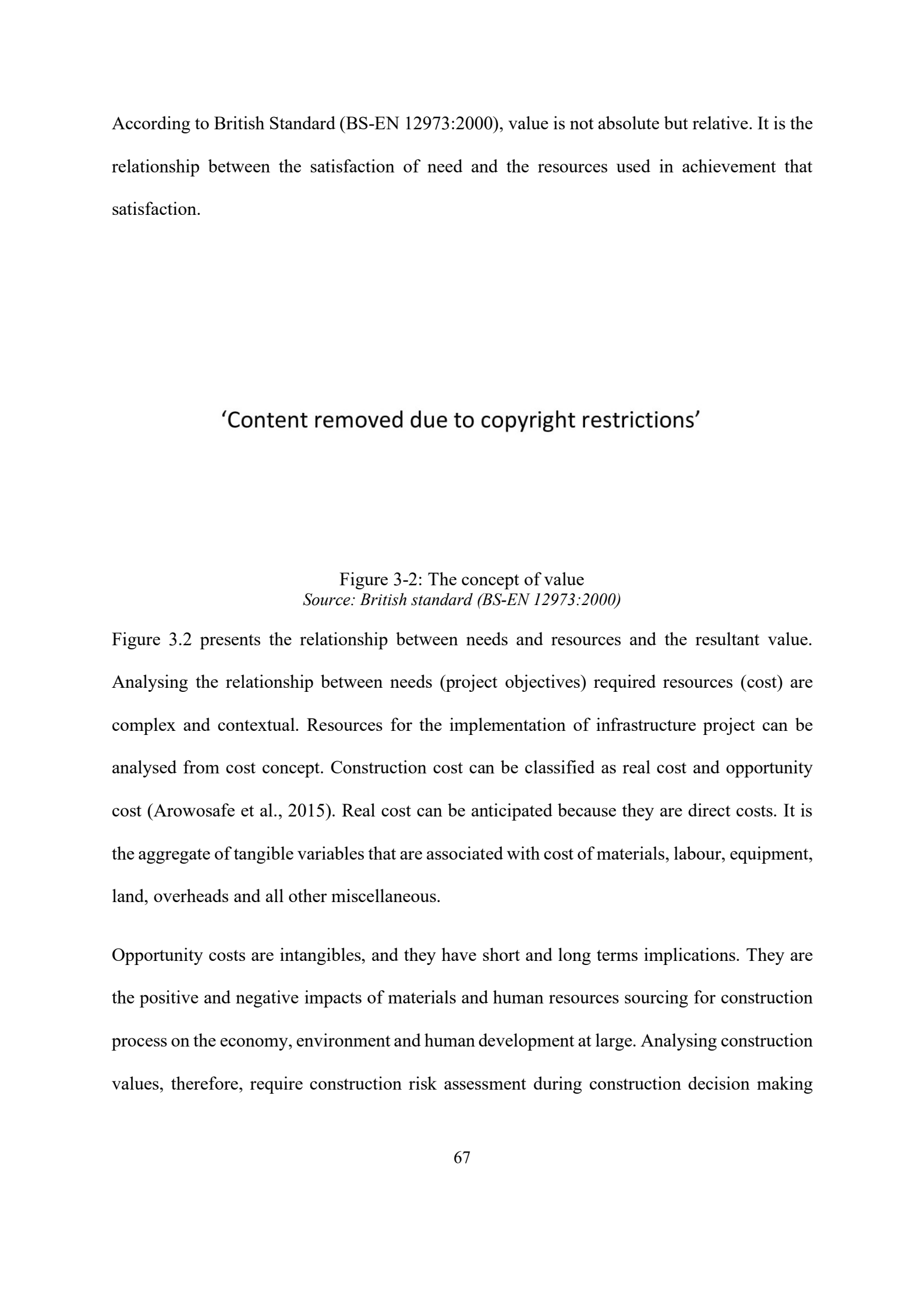

Figure 3-2: The concept of value
Source: British standard (BS-EN 12973:2000)

Figure 3.2 presents the relationship between needs and resources and the resultant value. Analysing the relationship between needs (project objectives) required resources (cost) are complex and contextual. Resources for the implementation of infrastructure project can be analysed from cost concept. Construction cost can be classified as real cost and opportunity cost (Arowosafe et al., 2015). Real cost can be anticipated because they are direct costs. It is the aggregate of tangible variables that are associated with cost of materials, labour, equipment, land, overheads and all other miscellaneous.

Opportunity costs are intangibles, and they have short and long terms implications. They are the positive and negative impacts of materials and human resources sourcing for construction process on the economy, environment and human development at large. Analysing construction values, therefore, require construction risk assessment during construction decision making

process (Male et al., 2005). Based on the analysis of real and opportunity costs, VfM involved the integration of quantitative and qualitative attributes (Walraven and de Vries, 2009).

3.4: Best Value for Money

Best Value was the United Kingdom initiative introduced in England and Wales by the Local Government Act (LGA) 1999. The UK Labour government introduced best value policy in 1997 to engage local authorities in high service standards initiatives (Akintoye et al., 2003). The policy was introduced to drive improvements and high standards in services offered by local authorities (Bukoye and Norrington, 2014; LGA, 1999). Section 3 (1) LGA) 1999 specified key attributes (economy, efficiency and effectiveness) for the government agencies to secure continuous improvement in the delivery of their functions.

At the time best value initiative was introduced in the UK, notable decline in construction productivity was alarming, with negative impact on national economy in the UK. Sir Latham was commissioned by the UK government to review activities in the construction sector. The report, released by Sir Latham in 1994, constructing the team, identified procurement strategy as driver to the industry's inefficiencies. It condemned traditional procurement route, which is best compared with 'hard system' approach of management; a strategy that promote fragmentation in construction process. Adversarial relationship and lack of respect for employees were identified as key barriers to productive procurement.

The interpretation of best value by Bukoye and Norrington (2014) is synonymous to VfM as analysed by the Department for International Development (DFID, 2011). The Department for International Development (DFID 2011) viewed VfM as maximising the impact of every penny spent on a project. It involved the consideration of all relevant costs-benefits over the entire procurement cycle (Raymond, 2008).

3.4.1: The 4 'Es' of Best Value for Money

With the shift from lowest price to best value tender, VfM in public domain is not just about saving money, rather ensuring best value for public investment. In what is termed "4 Es value for money framework", Department for International Development (DFID 2011) developed a flow chat for achieving VfM. This is adapted in Figure 3.3 to illustrate how the model could be contextualised in infrastructure procurement to deliver optimum results.

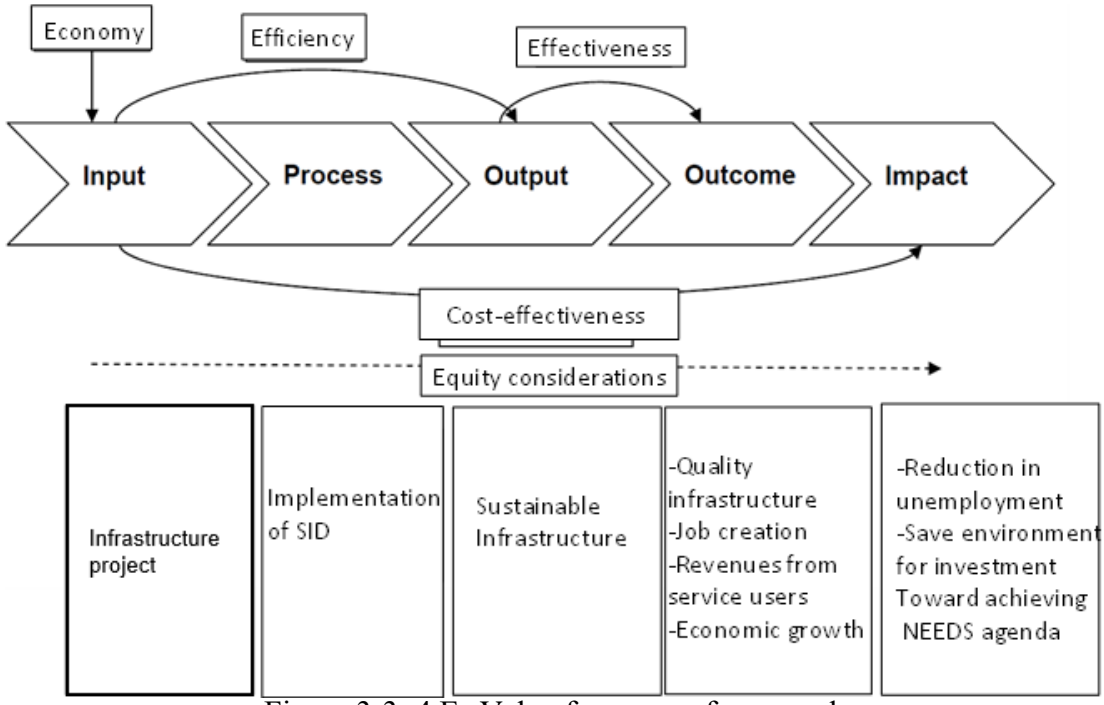

Figure 3-3: 4 Es Value for money framework
Source: Adapted from DFID (2011)

In addition to the 3Es (economy, efficiency and effectiveness) specified by LGA (1999) as drivers for better performance of the local authorities, Figure 3.3 reflects the importance of 'Equity' in the entire process.

1) *Economy: It evaluates the economic implications of the inputs in terms of quality and cost. Inputs include materials, capital, human resources.*

2) *Efficiency: It focuses on the process that transforms input to output. How well is inputs converts into outputs?*

3) *Effectiveness: This is gauged based on the evaluation of the output against set out objectives.*

4) *Equity: fairness: This focuses on fairness in the process. Is the process fair and ensure equal opportunities to the stakeholders irrespective of age, gender or influence? Are actions taken without favouritism or discrimination?*

3.4.2: Best Value in the Nigerian Public Sector

Despite the growing knowledge on Best value and increasing demand for public authorities to improve quality and cost service delivery, inadequacy of Best Value practices in public services in Nigeria and DC persist (Bukoye and Norrington, 2014). The trend is not unconnected with contemporary issues in DC. For instance, weak government structure and policy were identified as drivers for under-evaluation or miss-management of values in construction sectors in DC (Chukwuemeka et al., 2011; Taylor, 2007), Intervention programmes for constructuction development in DC are a '*propaganda*'. Ofori (2001) associted lack of Best value with:

- *inappropriateness of some of the recommendations and the initiatives adopted*
- *poor executive capacity of the implementing agencies*
- *lack of resources for implementation of initiatives*
- *neglect of the construction industry by governments and their lack of commitment to solving its problems*
- *absence of measurable targets in programmes for improving the industry's performance*

In Nigeria context, Bukoye and Norrington (2014) conceptualised best value model to fill the gap in research.

Figure 3-4: Best value model for Nigeria (BVMN)
Source: Bukoye and Norrington (2014)

Figure 3.4 is conceptualised based on the essentials of better performance in public service delivery (DFID, 2011; LGA, 1999). It reflects essentials of BVMN, which are grouped under 3 sub-section

3.4.2.1: The 4Es

The 4Es are the key essentials for best value initiatives. They are well elucidated in Figure 4.2

3.4.2.2: The 7 themes

The 7 themes summarise barriers to public service reforms i.e. Best value in Nigeria. The highlighted have been discussed by researchers (Chukwuemeka et al., 2011; Taylor, 2007; NCPAR, 2000) as barriers to sustainable procurement practice in Nigeria. Promoting enabling environment for best value starts from a leader who uphold value management. Transparency should be emphasised at all times in procurement process to eliminate corruption. While enhanced budgetary is recommended for public authorities, private sectors should be encouraged to invest in public service delivery.

3.4.2.3: The 4 Cs

The 4 Es are either incomplete or passive without actualisation of the 4 Cs (LGA, 1999). 'Challenge,' 'Compare', 'Consult' and 'Compete' are key elements for achieving continual development in a formulated policy by the public authority. The authority must strive to learn from the similar system to evaluate the success of the policy. It starts from self-assessment. The progress or outcome of a formulated policy can be compared with a similar policy. Lesson can be learnt, or knowledge gained through consultation. Public authority must be willing to compete with similar authority in achieving Best Value.

3.5: Procurement Strategy

Principal approach used by clients to achieve best value in infrastructure delivery is procurement strategy. It is a planned process undertaken by construction client to procure constructed facilities. Therefore, making the right choice of procurement strategy is very important to achieve value for money (Palaneeswaran et al., 2003). In general, procurement strategy is underpinned by decision made on tender options, the choice of construction contracts, and choice of procurement route.

3.6: Achieving Best Value for Money through Tender Process

Best VfM in PPP project is the aggregate of short- and long-term benefits. These values depend crucially on contractor selection, and it predicts infrastructure's sustainability. The selection process commonly entails five components, and they are project packaging, invitation, prequalification, shortlisting, and bid evaluation (Ogunsemi and Aje, 2006). Work packages provide in-depth information on the proposed project and it serve is the basis for contractors' pricing. Construction tender process is the combination of contractors' pre-evaluation and tender evaluation. A tender is a submission made by a prospective construction contractor in

response to an invitation to tender for construction project. It is a common practice that contractors are pre-evaluated on project specific critical criteria. It helps to reduce potential reducing contractors to a reasonable/manageable number for bid submission. This is followed by the bid acceptance for successful contractors. Common tender options for construction clients are open tendering, selective tendering, and negotiated tendering.

3.6.1: Pre-qualification Evaluation of Contractors

Contractor selection has long been dominated by lowest price consideration. The nature of contracting arrangements often promotes adversarial industry with significant potential disputes between client and contractors. Though selection process commonly involves elements; project packaging, invitation, pre-qualification, short listing, and bid evaluation (Cheng and Li., 2004), it is commonly considered as the function of pre-qualification and bid evaluation (Enshassi et al., 2013; Doloi, 2009; Cheng and Li, 2004).

Pre-qualification involves client's gaining more insight on the potential contractors that are invited for scrutiny (Enshassi et al., 2013). The process allows for the comparison of client criteria against attributes of potential bidders (Enshassi et al., 2013; Ogunsemi and Aje, 2006; Cheng and Li, 2004), which in public context span beyond lowest tender price. Equally, sustainability issues are managed during selection process to gain full commitment of project stakeholders (Abidin and Pasquire, 2005). By doing so, non-competent contractors are eliminated at the early phase of selection process (Enshassi et al., 2013).

Meanwhile, lowest tender price is commonly used as a pre-requisite for winning bid (Walraven and de Vries, 2009). Lower price based contractor selection, as a cost saving strategy is a misconception (Palaneeswaran et al., 2003). Though it might be productive in a small scale project, the approach is non-substantial to deliver best value for public clients due to premonition of contractor to tender unrealistic price just to win the contractor. Walraven and de Vries (2009) expressed concerned with manipulations of specifications that might arise in design and build contract where unrealistic tender price was accepted the contrator. Preference of lowest bid evaluation approach in public procurement has been attributed to the following:

1) *Transparency is guaranteed*
2) *It is a well-tested method and easy to implement*
3) *It is supported by law and regulations*
4) *It is a preferred evaluation method by project financier, such a World Bank*
5) *Many clients still consider low price as best value strategy*
6) *It is commonly accepted in many occasions where prequalification process is observed*
7) *Unwillingness of client to invest on alternative awarding process*
8) *Ignorance of clients on alternative methods* (Enshassi et al., 2013; Palaneeswaran et al., 2003)

Many project failure attributes can be mitigated through thorough review contractor selection at the planning and pre-construction phase. Ogunsemi and Aje (2006) identified effects of wrong choice of contractor significantly contribute to disputes and abandonment of projects, substandard work, cost and time overrun.

A succession of reports had considered how to promote VfM in contractor selection. Of a significant importance in the recent time is publication of the Latham report -Constructing the Team'. The UK government commissioned an inquiry panel headed by Sir Michael Latham to investigate contributing factors to under achievement and wastage in the UK construction industry (Latham, 1994). The report attributed lowest price practice to ineffective, adversarial

and fragmented industry. The report proposed a shift from traditional method of contractor selection (characterised with lowest price) to partnering.

Partnering involves agreement between client and contractors to work together to achieve best project performance through agreeing mutual objectives, deriving a way of resolving any dispute amicably, and committing themselves to continuous improvements through information sharing, measuring progress and sharing gains (Latham, 1994). One of the key processes towards achieving mutual objectives among conduction team is the understanding of the interests of the parties as it reflects in criteria for selecting contractors.

3.6.2: Selection Criteria and Contractors' Performance

Broadly, in the literature, cost, time, and quality are used to gauge performance of contractors. While these attributes remain decisive measures, extant literature only explore these attributes from economic stance. Numerous attempts have been made by researchers to elucidate criteria for selecting contractors for construction projects (see Enshassi et al., 2013; Doloi, 2009; Cheng and Li, 2004; Palaneeswaran et al., 2003; Mahdi et al. 2002; Fong and Choi, 2000; Palaneeswaran and Kumaraswamy, 2000; Wong et al., 2000); Hatush and Skitmore, 1997a; Hatush and Skitmore, 1997b). While selection criteria are well developed in the literature, there is no concesus on the contractors' selection criteria for PPP infrastructure projects. Due to misjudgement between lowest cost and best VfM, traditional criteria are often adopted for PPP contracts. The emerging theory in public procurement (refer to chapter 1) identified the missing gap and indicated the importance of social attributes in contractors' selection criteria for PPP infrastructure projects.

In general, lack of benchmark for contractor selection in public sector has been attributed to the popularity of the application of conventional selection criteria among public clients (Palaneeswaran et al., 2003; Palaneeswaran and Kumaraswamy, 2000). Traditionally, contractor selection is demand driven (Walraven and de Vries, 2009). The application of value is commonly confined within the scope of cost, time and quality (Dallas, 2006).

To delineate benchmark criteria for contractor selection, many researchers have looked for attributes that could be used to qualify a best approach. For instance, Walraven and de Vries (2009) advocated for 'value driven' contractor selection. Palaneeswaran et al. (2003) explored how public client can optimise value for money through 'best value focused' contractor selection. Wong et al (2000) made a case for the abolition of lowest price practise and the embracement of 'project specific criteria' during contractor pre-qualification evaluation. Walraven and de Vries (2009), Palaneeswaran et al. (2003) and Wong et al. (2000) emphasised on the importance of a shift from demand driven to value driven. Though public client enjoys less freedom in contractor selection (Palaneeswaran et al. (2003), the approach explores cost elements of the contractor selection beyond tangible elements. Construction cost can be classified as actual cost and opportunity costs (Arowosafe et al., 2015). Actual cost is easily anticipated. It is the aggregate of tangible variables. Actual cost is measured based on cost of factors of production, overheads and profit margin for contractor. Opportunity cost considers overall impacts of alternatives that are ignored.

Hypothetically, the meaning of a client in a context influences component for selection criteria. However, with the dominance of BOT procurement strategy in Nigeria, a shift from a client-focused to stakeholders-focused influences the process of eliciting evaluation criteria for the extant literature.

After thorough review of literature, fifty-five criteria that are relevant to pre-qualification evaluation for contractor were identified. These criteria are grouped under relevant contractors' pre-qualification factors. The summary of criteria is presented Table 3.2.

Table 3-2 Prequalification contractor selection criteria

References	Pre-qualification Factors	Criteria
Watjatrakul (2014); Enshassi et al. (2013); Doloi, 2009; Kumaraswamy and Ng, (2003); Mahdi et al (2002); Wong (2000); Hatush and Skitmore (1997); Zedan and Martin (1997); Gary et al. (1994)	Financial Capability	-Working and operating capitals -Bank arrangement guarantee -Yearly turnover history -Employee wellbeing -Taxes clearance
Watjatrakul (2014); Enshassi et al. (2013); Doloi (2009); Kumaraswamy and Ng (2003); Wong (2000); Hatush and Skitmore (1997a); Zedan and Martin (1997)	Technical Capability	-Experience in project of similar nature -Suitability of equipment to project capacity -Availability of equipment -Training and skills level of craftsmen -Proposed construction methods -Project control and monitor procedures
Watjatrakul (2014); Enshassi et al. (2013); Doloi (2009); Wong (2000); Zedan and Martin (1997)	Management Capability	-Site organisation -Construction progress reporting systems -Project management experience -Knowledge of outsourcing -Knowledge of local environment -Cooperation with workers' union -Knowledge of labour law -Ability to deal with unanticipated problems -Quality and quantity of human resources -Quality and quantity of managerial staff -Current work load -Willingness to update technology and share risk
Watjatrakul (2014); Enshassi et al. (2013); Doloi (2009); Kumaraswamy and Ng, (2003); Mahdi et al (2002); Wong (2000); Zedan and Martin (1997)	Reputation	-Ability to complete on time -Work quality achieved in similar work -Length of time in business -Relationship with sub-contractors -Relationship with suppliers -Relationship with insurance companies -Relationship with local authority -Claims and disputes history -Comparison of client's estimate with tender price -Cost control and reporting system
Watjatrakul (2014); Enshassi et al. (2013); Doloi (2009); Cheng and Li (2004); Kumaraswamy and Ng (2003); Wong (2000); Zedan and Martin (1997); Ngowi (1998)	Health and Safety	-Safety of machineries -Adequate training for operating process -Personal protective equipment -Culture fit with host community -Site organisation rules and policies -Contractor familiarity with geographic area -Site safety records

Kumaraswamy and Ng (2003); Palaneeswaran and Kumaraswamy, (2000); Wong (2000)	Local Growth	-Employment creation for locals -Local material sourcing -Knowledge transfer -Contractor familiarity with local suppliers -Contractor familiarity with local labour -Contractor social responsibility initiatives
Kumaraswamy and Ng (2003); Palaneeswaran and Kumaraswamy, (2000), Ngowi (1998)	Life Cycle Costing	-Operation costs -Maintenance cost -Deconstruction and replacement
Kumaraswamy and Ng (2003); Ngowi (1998); Hill and Bowen (1997)	Minimal environmental impacts	-Environmental management certification -Waste and recycling -Control of pollution and hazardous substances -Reduction in energy usage -Reduction in water usage -Selection and use of materials

3.6.2.1: Financial Capability

Project finance is essential in public infrastructure delivery. Lack of funding is one of the contemporary issues in public procurement in DC (Oluwakiyesi, 2011; Ebohon et al., 2002; Kaming et al., 1994). Project performances are affected by availability of funds in many ways. Extension of time may result due to lack of capital flow. The resultant delay is higher cost of project. Quality of materials may be compromised when funding is not readily available. Due to knowledge and past-experience, public clients are keen to ensure that potential contractor can demonstrate financial buoyancy to ensure smooth project delivery.

3.6.2.2: Technical Capability

Delivery of capital projects requires technical ability of contractor to deliver high performance projects. More often, technical capability may be associated with level of training acquired by the contractor. Also, experience gained from a previous project gives a contractor and an added advantage over competitor in bidding process to prove their competency in delivery value added project. Contractors with past experience in similar project potentially have gained good knowledge of innovative method to apply in the process of sourcing plant and experience of technical personnel that meet project requirements.

3.6.2.3: Management Capability

Construction is aggregate of various specialised trades. Management expertise encompasses specialist knowledge about these trades and external environment. Managerial skills are, therefore, essential for the planning and the coordination of factors of production, taken cognise of associated risks and value management. Ability to demonstrate knowledge of project development environment and related regulations and governing bodies are also very important for a prospective contractor to guarantee sustainable infrastructure delivery (Doloi, 2009).

3.6.2.4: Reputation

This refers to all behavioural attitudes among construction team and they determine length of working relationship (Doloi, 2009). Key reputations sorted by a client during prequalification of contractor history of quality performance (Idoro, 2010). Since construction project is fragmented, comprising of specialised trades and suppliers, it is good to gain knowledge with sub-contractors, suppliers and financial/insurance institution. History of claims and disputes would further inform client on potential additional cost through compensation claims by contractor.

3.6.2.5: Health and Safety

Health and safety issues in construction process are multi-facets. They include handing of materials, equipment, and structural specifications. Physical and environmental conditions can also pose significant hazards. Lack of awareness to construction risks and safety measures contribute significantly to high construction cost. Past safety records of a contractor give a respite to potential client on likely success of prospective project. Bad safety records can be attributed to poor work ethics, skills deficiency, lack of innovative approach and technology (Fernz et al., 2013; Idoro, 2010; Adams, 1997). In case of accident, those affected may include

people on site or public. Severity may include loss of constructed facility, and worst scenario, loss of lives. A potential best value contractor must be able to demonstrate sound safety records (Palaneeswaran et al. (2003).

3.6.2.6: Local Growth

Palaneeswaran et al. (2003) and Palaneeswaran and Kumaraswamy (2000) shared similar opinions on best practice best value procurement. As an ethical requirement, contractors must be able to demonstrate strategic plans towards growth of local industry and community in their supply chain management. Employment creation is obviously one of the challenges of DC. A contractor with employment creation strategies would support itching plan of poverty eradication. Acceptance of a contractor by the community will further boost their acceptance. This will also improve accuracy of cost forecast (Arowosafe et al., 2015).

3.6.2.7: Life Cycle Costing

Life Cycle Costing (LCC) is an economic model to establish total cost of asset ownership. The framework is designed to address infrastructure cost elements; operational and running cost, that make up cost profile of infrastructure throughout their effective life. The technique also provides support policy makers in decision makers when faced with choice of product (HM Treasury, 1992). LCC is a useful tool at pre-construction phase when decision is made on contractor selection since it involves cost breakdown structure.

Palaneeswaran and Kumaraswamy, (2000) contended that life-cycle cost analysis is the appropriate method of analysis when evaluating alternatives which are competing for limited funds. As applicable in private funding strategies for public infrastructure, the growing popularity of BOT is attributed to comparative advantages over other models on risk management (Cheung and Chan, 2009). The contractual agreement is based on granting of

concession to private entity (Al-Azemi et al., 2014). Concessionary period could be up to 25 years or more. During the concessionary period, public borne operation and maintenance costs, being service users. At the end of the contract, infrastructure is then transferred to the public that now continue with the maintenance and eventual disposal at the end of usable life span.

Usually, the cost of operation, maintenance, and disposal costs is most significant (see Figure 3.5). The principle of discounting future implies provision can be made for maintenance work in future time by making provision today.

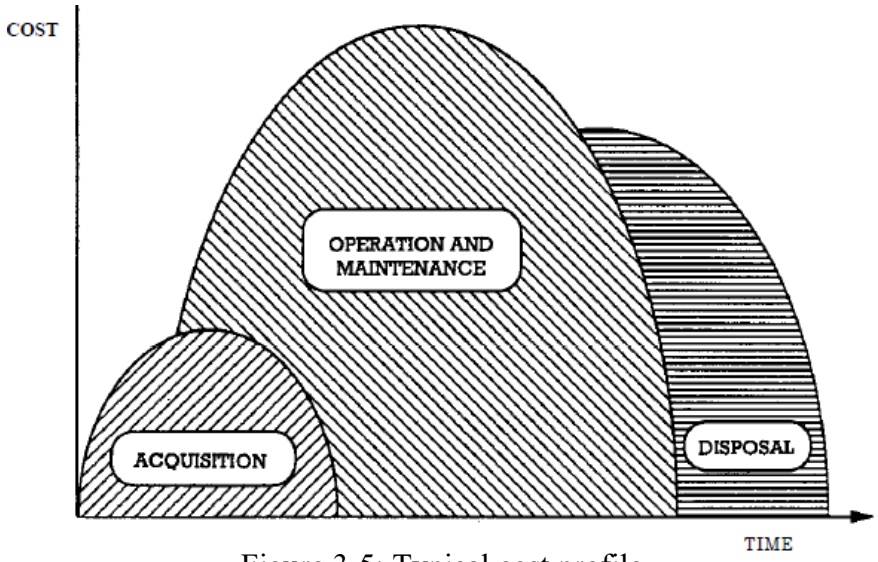

Figure 3-5: Typical cost profile
Source: HM Treasury (1992)

Useable life in infrastructure at the end of concessionary period could be a function of materials used and maintenance work. Also, of important is available of regular funds to carry routine and periodic maintenance work. Since, operation and maintenance costs are functions of empowerment of end users, it is a good practice to forecast capability of end user to afford charges during the function period of assert. Adequate measure is therefore required to ensure that users are able to sustain operational and maintenance cost through service users charges.

3.6.2.8: Minimal Environmental Impacts

The environmental impacts of construction activities are considerably high (Du-Plessi, 2002; Ngowi, 1998). Environmental issues include reliance on non-renewable energy, depletion of forest, waste generation and destruction of eco-system (Ngowi, 1998). Stages of potential environmental impacts of construction process are design, production and distribution. A contractor that is environmentally conscious will in no small measure add value to infrastructure delivery through resources management and control of environmental impacts.

3.7: Choice of Procurement Routes in Construction

A plethora of approaches for procuring construction projects are available to meet the needs of clients. Common categories of procurement routes include traditional, management contracting, construction management, design and build and private finance initiative (Pryke, 2009). Uniqueness of each approach is defined by level of obligations and risk management among parties.

With the time timeline of sustainable development, there has also been a better understanding of the contribution of construction to sustainable development. A graduate change on the evaluation of successful procurement has further occurred in public sector. In global construction context, social procurement has been transformed to a new paradigm for contractor selection that delivers best value. Social sustainability is fast becoming a tender requirement that a contractor must satisfied during pre-evaluation process.

While, partnering is a welcoming idea, social sustainability is critical in best value criteria to satisfy equity and make it more robust and beneficial to social development. EU Directive (Directive 2004/18) mandate that evaluation of contractors is not exclusively gauged on their proficiency for the delivery of quality infrastructure; they must be able to demonstrate how the delivery process will contribute to social progress. In 2013, Social Value Act was introduced in the UK, which mandates the inclusion of social value principles in the procurement policies by the local authorities. A reference to the UK is critical in this study because Nigeria was once a colony of the UK. The current practise in the public sector could be date back to the period of colonial rule (Bukoye and Norrington, 2014). Review of lessons learned of VfM in the UK is important in serving as benchmark for best practice.

3.8: Current Trends of Decision-Making Techniques for Contractor Selection

Though the application of a theoretical framework provides basic criteria selection (Oyedele and Tham, 2005), it is rarely possible for a contractor to demonstrate comparative advantages in all selection criteria. For instance, a contractor may guarantee lowest cost, but overall quality may be impaired due to poor safety measure resulting in high casualty.

Asadzadeh et al. (2015) argued that in a complex decision problem, individual indicator weighing remain big challenges in decision making for many reasons:

i. *Failure of composite indicators to captures the interconnectedness of indicators*
ii. *Eliminate important dimensions that are difficult to measure*
iii. *Hide weaknesses in some components*

During evaluation process, criteria are compressed to key specific criteria that are used to measure suitability of a contractor for a specific project (Cheng and Li, 2004). Results are aggregated to identify optimum choice among evaluated contractors (Cheng and Li, 2004).

Various methods have been developed to evaluate contractor selection (Enshassi et al., 2013). Enshassi et al. (2013) had conducted extensive study on the commonly applied methods for contractor selection. The study provides principal characteristics, which can inform decision making on making the choice of selection method. The summary of the findings of the study by Enshassi et al. (2013) is presented in Table 3.2.

Table 3-2 Summary of developed methods for contractor selection

Source: Adapted from Enshassi et al. (2013)

3.9: Public-Private-Partnership (PPP)

Public Private Partnership, or simply P3, is widely regarded as the future of infrastructure projects. It is a contractual agreement between the public and private sector aimed at utilising the expertise, skills, assets and financial resources of both sectors to deliver optimum value to the public. It is a mode of providing public infrastructure and services by government agencies

in partnership with the private sector. Generally, it encompasses operation and maintenance of the constructed facilities throughout the entire contract term, which normally referred to as the concession period, usually 25-30 years (Oyedele, 2013).

PPP strategy is used globally to encourage private sector participation in the delivery of physical infrastructure and services for public (Carbonara et al., 2015; Al-Azemi et al., 2014; Tsai et al., 2012; Ke et al., 2012). Public infrastructure projects, such as bridges, roads, hospitals, schools, etc., are procured through private entity that could be responsible for their finance, design, construction, management, and operation. The popularity of PPP among public clients has instigated volume of studies be conducted on the risk appraisal of PPP projects (see Al-Saadi and Abdou, 2016; Al-Azemi et al., 2014; Loxley, 2013; Tsai et al., 2012; Ke et al., 2012; Yuan et al., 2009). Generally, P3 involves granting of franchise or concession by the public or private to private entity referred as the concessionaire (Al-Azemi et al. 2014). Concessionaire, otherwise known as project consortium or special purpose vehicle (SPV), is a group of private investors. The team is made of project managers, engineers, designers, contractors and financial experts. SPV provides funds for the construction of infrastructure and operate it for agreed period before the structure is returned to the public (Opawole and Jagboro, 2016a; Carbonara et al., 2015; Trebilcock and Rosenstock, 2015; Al-Azemi et al., 2014; Oyedele, 2013; Tsai et al., 2012; Ke et al., 2012). The team also take the responsibility for the project finance, construction, operation and maintenance of constructed facilities over concession period (Opawole and Jagboro, 2016a; Carbonara et al., 2015; Trebilcock and Rosenstock, 2015; Al-Azemi et al., 2014; Oyedele, 2013; Tsai et al., 2012; Ke et al., 2012). During concessionary period, fund raised from services charges are spent towards operational, maintenance and recoup of invested capital. The project is then return to the owner at the end of the concession period at no cost. Figure 3.6 present a typical supply chain P3.

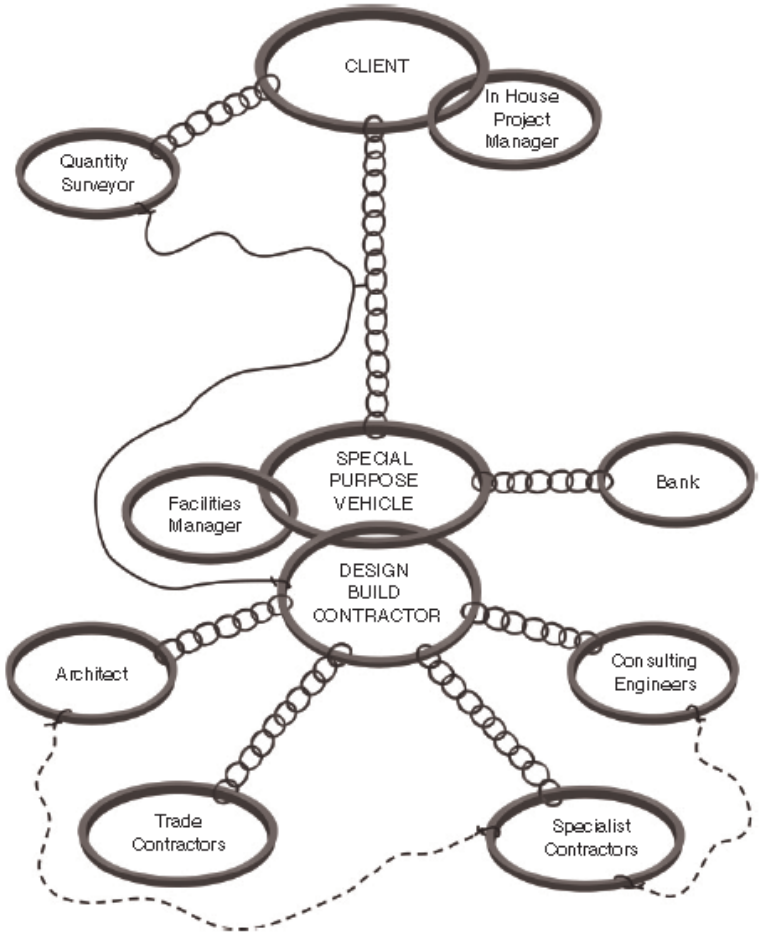

Figure 3-6: Typical supply chain – PFI
Source: Pryke (2009)

There are assertions that P3 related models have been experimented in some countries over the past centuries, but the first conception has been debatable. However, the modern P3 is highly associated with the infrastructure development in the UK in 1992 (Opawole and Jagboro, 2016a). At the time, the modus operandi for project delivery was branded Private Finance Initiatives (PFI) (Oyedele, 2013). Though Akintotoye et al. (2003) made a distinct of PFI as a form of PPP where project financing is bored wholly by the private sector, both PPP and PFI are interchangeably used in literature (see Pryke, 2009).

It is often common for the definition of PPP to vary from country to country (Robert et al., 2014) but their modes are almost the same. For Nigeria, ICRC publications give insight to how PPP in Nigeria can be interpreted in terms of definition, and their attributes. PPP as defined by the national Council for Public Private \Partnerships, cited in ICRC (2012):

> *"it is a contractual agreement between a public agency (federal, state or local) and a private sector entity. Through this agreement, the skills and assets of each sector (public and private) are shared in delivering a service or facility for the use of the public"*

PPP as defined by HM Treasury, 1998, cited in Roehrich et al. (2014) as:

> *"an arrangement between two or more entities that enables them to work cooperatively towards shared or compatible objectives and in which there is some degree of shared authority and responsibility, joint investment or resources, shared risk taking, and mutual benefits"*

In the context of this study the definition of PPP by HM Treasury is applicable as benchmark for best practice. It recognises that in practice, conflicting interests are inevitable, during key decision-making process. Interests of the parties are achievable in openness and transparent process.

Result of a study by Robert et al. (2014) on the reasons for growing popularity of PPP is summarised in Table 3.3.

Table 3-3: Summary of reasons for PPP

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Source: Robert et al. (2014)

From the 17 reasons for preference of PPP as identified in the literature (in Table 3.3), Robert et al. (2014) concluded that five most important reasons were “reduces public sector administrative cost’, ‘allows for shared risk’, ‘reduces the problem of public sector budget constraint’, ‘private sector possess better mobility’ and ‘private sector has ability to raise funds for project”. Overall, reasons identified in the literature on the preference of PPP for public infrastructure procurement are economy and budgetary underpinned. Many government agencies, most especially in DC, are only keen to procure infrastructure project from a sustainable source rather than procuring sustainably. This further validated limited knowledge of social sustainability in infrastructure procurement.

3.9.2: Critical Success Factors for PPP projects

Despite the benefits that are associated with the PPP; the concept is faced with criticism in some quarters. Two hypotheses that often-influenced public views due to risks assertion for two main reasons (Patil et al., 2016); (1) these is a fear of lack of employment opportunity and unfair work condition by concessionaire, (2) there is a general theory that private entity is profit driven, and hence service users are left to bear high-cost burden over a concessionary period.

A list of scholarly researchers has adopted diverse views on critical success factors for PPP projects. In more recent publication by Al-Saadi and Abdou (2016), five most critical success factors (CSFs) for PPPs projects were identified as (1) availability and effectiveness of proper regulatory and legal framework for PPPs, (2) proper risk allocation and sharing among project stakeholders (3) clear project brief and client outcomes, (4) comprehensive and business viability of project feasibility study, and (5) proper project value management systems during different project phases. The overall factors can be discussed from cost and ethical stances. More importantly, success of trade-off between the two factors is proportional to risk appraisal and management. Li et al. (2005) carried out an extensive study on critical success factors (CSFs) for PPP projects. The Summary of CSFs for PPP projects in Table 3.4.

Table 3-4 Summary of CSFs for PPP projects

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Source: Adapted from Li et al. (2005)

3.10: Streams of PPP Compared

There are various options of P3s that is available to public client to procure infrastructure project. The choice will be influenced by the compatibility of the attributes of the options with the perceived best value criteria in a project. Traditionally, modes of PPP are compared on the degree of risk transfer from public sector to private entity.

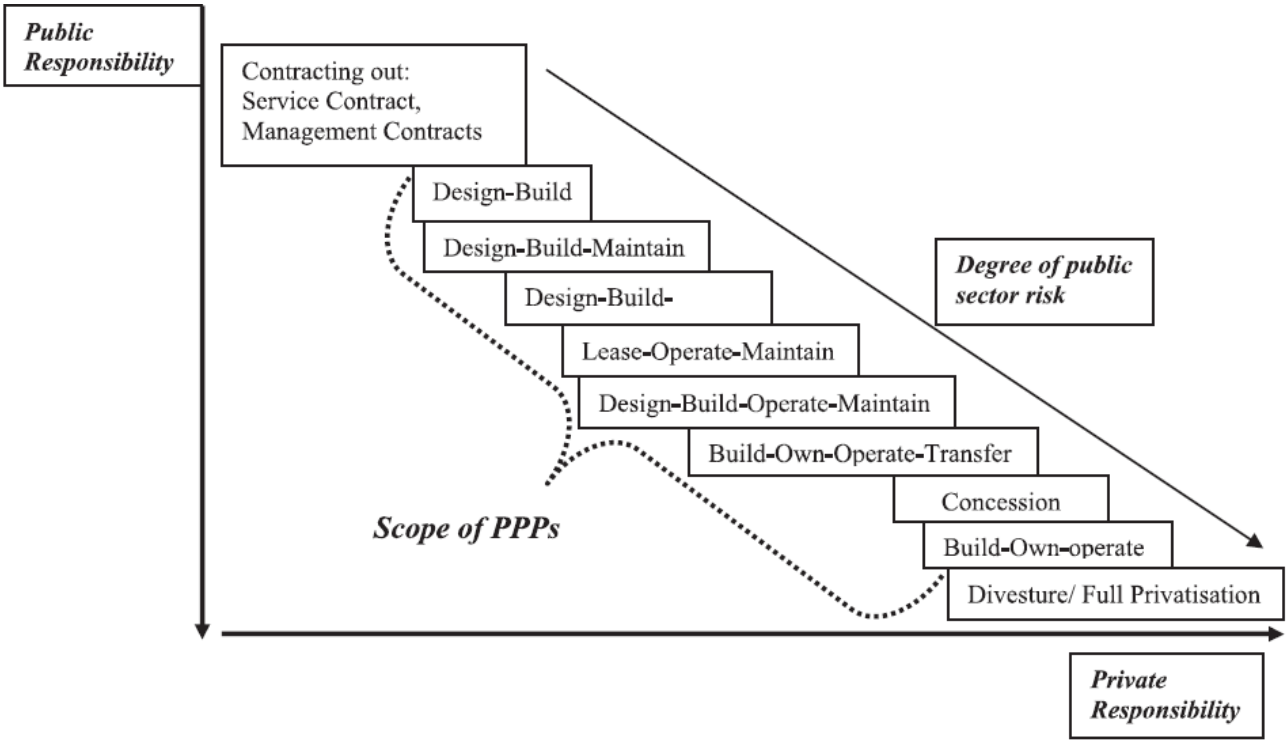

Figure 3-7: Scale and scope of private and public responsibility
Source: Roehrich et al. (2014)

Figure 3 7 illustrates scale and scope of private and public responsibility in PPP. There are many modes of PPP in the literature. Some modes are found to be same function different names, depending on the country e.g., Design-Build-Finance-Operate (DBFO) in known outside the USA as BOT. In some cases, it is contextualised in usage in a country, for instance, "Landlord Port Model" for the Nigerian ports in line with the ports reform programme (LPM) (ICRC, 2012). Following extensive literature review, key modes of PPP are summarised in Table 3:5.

Table 3-5 Modes of PPP compared

Modes	Characteristics
Design-Build/Turnkey	The private sector designs and builds infrastructure at a fixed price. Risk of cost overrun is bored by the private sector
Management contract	Private entity is contracted to manage public projects, such as utility, port services, and hospitals. The public sector is responsible for major capital investment. A fee for the service of the private sector and the operating costs are predetermined, though it can be agreed that the private sector is paid a specific percentage of profit. Private sector also receives additional rate anytime a milestone achievement is reached.
Lease and Operate Contract	Public project is leased to a private entity who assume all management, operation and service of the facility\
Concession	In concession contract, private entity provides the service, while public sector regulates price and quality of service. Tariff is set up by the concession contract and with terms and conditions for changes over time. The concessionaire is responsible for the full delivery of service, which include finance, construction operation, maintenance, collection of charges, and rehabilitation of the service. In rare cases, public sector can raise capital to support project funding. Infrastructure assets under concession contract is owned by the public sector during concession period. During the concession period (typically 25 – 30 years), public sector set up performance standard that concessionaire complies with. Concessionaire recovers construction cost, overheads and profits during the concession period.
Lease contract	-Private sector is responsible for the service in its entirety at his expense and risk. The risks bored by the private sector are financial, operation, and maintenance risk, and loss of unpaid consumers' debts. -Obligations of private entity includes quality and service standard except for new investment, which public sector is obliged to. -Typical duration of the least contract is 10 years or above and may subject to renewal. Lease payment is contractually agreed.
Build-Operate-Transfer (BOT)	-There are many variations of BOT, and they include build and transfer (BT), build, transfer and operate (BTO), build, operate and own (BOO), build, operate, own and transfer (BOOT), operate and transfer (OT), reconstruct, operate and transfer (ROT) (Al-Azemi et al., 2014). In the USA BOT is known as design-build-finance-operate (DBFO). -Generally, BOT is a specialised concession mode. According to ICRC (2012), concession involves extensions to and operation of existing systems. BOT commonly involves large greenfield investments that requires substantial finance. The difference between BOT and concession -Private sector or private consortium finances and develops a new infrastructure projects in compliance with performance standards set up by the private sector. -Private sector owns the assets for a period that is agreed upon in the contract. -Investment costs are recovered through charges on service during the period. In some cases, private sector agrees to purchase some percentage of output to guarantee that private sector recovers its capital investment during operation. -At the end of concession period, public sector can choose to take charge of operation, contract the operations responsibility to the developer, or award a new operating contract to a new partner.
Build-Own-Operate (BOO)	Private entity finance, build, owns and operates infrastructure in perpetuity. It is guided by the agreement and on-going regulatory obligations
Design-Build-Finance-Operate (DBFO)	-It is considered as the simple and conventional P3s model -Private entity finance, design, build and operate a project for a concession period -The facility is then transferred back to public ownership

3.10.1: Build-Operate-Transfer (BOT) Procurement Model

BOT model is often referred as core PPPs because a substantial number of risks being transferred to the private sector (Carbonara et al., 2015; ICRC, 2012). A list of acronyms is found to be linked to BOT, and the include OT (operate-transfer); BT (build-transfer); BTO (build-transfer-operate); BOOT (build-operate-own-transfer) (Tsai et al., 2012), and DBFO (Robert et al., 2014).

The popularity of BOT modes among public clients has further instigated volume of studies being conducted on risk appraisal (see Al-Saadi and Abdou, 2016; Al-Azemi et al., 2014; Robert et al. 2014; Tsai et al., 2012; Ke et al., 2012; Yuan et al., 2009). Risks that associate with BOT are multi-facets. Different approaches have been applied in the classification of risks in BOT projects. They include country risk, financial and revenue risks; promoting and procurement risks, development risks and construction and operating risks (Al-Azemi et al., 2014).

Broadly, Tsai et al. (2012) categorised risks of BOT projects under project development, implementation and financial risks, which can be expressed as heavy investments, high costs for tender planning, long project lead times, high investment, long contractual negotiation periods and high leverages risks.

BOT method of delivery public infrastructure projects is not a new idea of procurement. It could be dated back to 19th century (Al-Azemi et al. 2014). Though the application has been on the increase in DC over the past decades, accounting for 17.9% of infrastructure delivery (Loxley, 2013), the model is still at the experimental stage in Nigeria as the first set of concession-based projects was commissioned around 2006 (Opawole and Jagboro, 2016).

The first concession-based project was lunched in Nigeria in 2006 (Opawole and Jagboro, 2016a). Until then, infrastructure finance was the sole responsibility of government. Askar and Gab-Allah (2002), cited in Cheung and Chan (2009) summarized ideologies of BOT approach:

1) *The use of private sector financing to provide new sources of capital, thus reducing public borrowing and improving the host government's credit rating.*
2) *The ability to accelerate the development of projects that would otherwise have to wait for scarce sovereign resources.*
3) *The use of private sector capital, initiative, and know-how to reduce project construction costs and schedules and to improve operating efficiency.*
4) *The allocation of project risk and burden to the private sector that would otherwise have to be undertaken by the public sector.*
5) *The involvement of private sponsors and experienced commercial lenders, providing an in-depth review and additional assurance of project feasibility.*
6) *Technology transfer, training of local personal, and development of national capital markets.*
7) *In contrast to full privatisation, the government's retention of strategic control over the project, which is transferred back at the end of the contractual period.*
8) *The opportunity to establish a private benchmark to measure the efficiency of similar public sector projects and thereby offer opportunities for the enhancement of public management of infrastructure facilities.*

3.11: A Case of PPP Infrastructure Projects in Nigeria

Prior 1999 (Nigeria fourth republic), key challenges of infrastructure delivery identified included lack of infrastructure master plan for the country. This was identified as the driver for ineffective and in efficient infrastructure planning and development (ICRC, 2012). The development of the National Integrated Infrastructure Master Plan was approved to guild infrastructure delivery.

In 2012, a total of 22 infrastructure projects (see table 3.6) were already at various phases of development through PPP procurement.

Table 3-6 Major PPP infrastructure projects initiated and implemented in Nigeria

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Source: Extracted from ICRC (2012)

In a recent publication by An Investor's Manual (2013), evidence abound of milestones in infrastructure delivery by the Nigeria government through concession-based initiatives. Most of the infrastructure are delivered through BOT strategy. According to Loxley (2013), evaluating performance of BOT in Nigeria and Africa, at large, remain mammoth tasks. This is due to high confidentiality that is commonly associated with individual projects and lack of knowledge sharing among countries. Knowledge is hardly shared and attributes of value for money are always kept in private. CUPE (1998), cited in Loxley (2013) referred to PPP initiatives as privatisation by stealth.

3.12: Evaluation of PPP Performance in Nigeria

According to Loxley (2013), evaluating performance of PPP in Nigeria, remain mammoth tasks. This is due to high confidentiality that is commonly associated with individual projects. Knowledge is hardly shared and attributes of value for money are always kept in private. This can be attributed to lack of transparency in procurement process.

The sustainability of bid evaluation and contractor selection for public projects in Nigeria has been a subject of concern over the past decades (Adams, 1995). The ideology of concession-based projects in Nigeria MDAs has been criticised as 'lowest price ideology rather than sustainability initiative (Taylor, 2007). Though the PPP strategy promotes competitive bidding, long term cost implications remain unresolved in DC, as contemporary issues linger on (Ajufo, 2013; Enweremadu, 2013; Omotola 2008; Taylor, 2007).

Most often, parties or stakeholders in PPP project are ill-evaluated. Opawole and Jagboro (2016a) viewed that failure of PPP projects in Nigeria could be attributed to ill-definition of parties' obligations. This assertion validates Babatunde and Low (2013) who argued that one of the main issues with project delivery in DC is lack of standardised value criteria.

Common prerequisite use to guage value for money in project delivery is cost reduction approach (Al-Azemi et al., 2014). The initiative is argued to relief government of the burden of shortage of finance and thereby by create an opportunity to focus on other financial commitment while consortium take charge of the delivery of constructed facilities.

Since inception, many PPP projects in Nigeria since 2006 are rated either failure (Ogunsemi and Aje, 2006) or with little success (Opawole and Jagboro, 2016b). Some of PPP projects are either terminated during construction phase or subject to renegotiation, which significantly altered projected project cost (Opawole and Jagboro, 2016a). PPP, to some critics is no different to traditional approach. As such the model fail to gain popularity in some quarters.

Enweremadu (2013) argued that private funding for public infrastructure is not sustainable. 'Finance driven' nature of concession-based projects has transformed the economy to consuming nation (Enweremadu, 2013). In most cases private entity obligation is to deliver constructed facilities, with freedom to source materials and manpower at their personal discretion.

Taylor (2007) made a case for the practice of Chinese owned construction company in Nigeria infrastructure delivery. Chinese companies had no considerations for the 'local content' of the host nations in DC and notable for corruption and poor safety measures. Yet Chinese corporations continued to dominate infrastructure delivery in Nigeria through financial aids to the government for infrastructure procurement and their ability to guaranteed lowest price.

Opawole and Jagboro (2016b) are concerned about PPP contract packages that are underpinned poor assessment of the socio-cultural and economic factors, which constitute parties' cost. Barriers to sustainable concession-based project include political interference and non-availability of supporting institutions (Opawole and Jagboro, 2016b). Furthermore, the needs of parties are often under evaluated. For instance, free flows of resources between national borders are drivers for increasing level of unemployment and social vices (Ajufo, 2013; Oluwakiyesi, 2011; Omotola 2008). International trade is the driver for unemployment and

social problems in the absence of mechanism that facilitate backward and forward linkages between construction sector with broader sectors of the economy.

Ogunsemi and Aje (2006) re-iterates the needs for better productivity and administration in construction sector. This issue is ethical undertone that is associated with stakeholders' perception of being neglected during decision making process.

3.13: Summary

Procurement strategy is one of the strategies to achieve sustainable construction procurement. PPP is now the key strategy used in the delivery of public procurement. This chapter started with the highlighted benchmarking and ethical issues in construction procurement.

The popularity of various modes of PPP is obvious among government agencies globally. The chapter elaborated on PPP, specifically on critical success factors for PPP projects and comparisons among different mode of PPP. The summary of critical success factors for PPP projects re-iterated the needs for the formation of objective benchmark among stakeholders in public-private collaboration for infrastructure delivery.

The review of the case of PPP in Nigeria showered that BOT was the commonly applied stream of PPP. In general, evaluating performance of PPP in Nigeria, remained mammoth tasks. While evidence abound on the significant improvement in infrastructure projects, there is no positive social impacts. The procurement practice was characterised with lowest price ideology rather than sustainability initiatives.

CHAPTER 4 : RESEARCH METHODOLOGY

4.0: Introduction

As stated in Chapter 1, the aim of this study is to develop a framework for contractors' selection that Nigerian government can use to achieve value in the delivery of sustainable infrastructure projects. This chapter presents the concepts that are used for research design and key statistical methods and software that are applied for data presentation and analysis. It also detailed the concepts that are used for research design and key statistical methods and software applied for data presentation and analysis. In addition, the methodological processes for analytical network process (ANP) are detailed incorporating the systematic and theoretical analysis of the research methods and the formulation of the framework for predicting selection of contractor that promoted SID.

4.1: Philosophical Position of this Research

Research philosophy, or paradigm, is a philosophical view, a mind-set, or a guiding principle, beliefs and values on how a researcher thinks logically in conducting a research. Philosophical assumptions help to justify questions on why data is collected, what data is collected, where it is collected, how it is collected and how it is analysed (Collis et al., 2003; Krauss, 2005). Furthermore, philosophical stance guides researcher's relationship with object under scrutiny and impose strict philosophies that define logical path of design process (Philips 1996).

The two main philosophical considerations in social research are ontology and epistemology (Bryman, 2008). These two positions are mostly considered in built environment studies. This research was conducted within the scope of contractors' selection criteria for sustainable infrastructure delivery in Nigeria. As highlighted in the previous chapters, PPP is now transferred to preferred procurement strategy for public infrastructure. This procurement option

consists of diverse stakeholders with economic and ethical stakes. While satisfaction of their interests is vital to the evaluation of the sustainability of the procured infrastructure, there are fundamental decisions that are critical to project performance.

Extensive literature review studies have been conducted regarding the selection criteria for contractors, with the theoretical frameworks that are based on sustainable development. Review of these criteria has allowed for scientific approach and bias free judgement on the best criteria for pre-evaluation of contractor that support SID. Based on the above, this study favours objectivism as an ontological consideration and positivism as an epistemological position within an overall quantitative research philosophy but has a degree of interpretivism in its qualitative aspect.

4.2: Construction Values Measurement from a Systemic Stance

The growing need for sustainable infrastructure delivery in PPP necessitates for an efficient and an efficient methodological process. As earlier highlighted in this Chapter, the essential for the actualisation of SI can be simplified under the triple bottom line. SID (a conceptual framework that is developed in this thesis) makes a case for the integration of social attributes during pre-evaluation process of contractors to obtain best value and achieve sustainable infrastructure. Under traditional procurement strategy, 'linear process' is often adopted, where each of the criterions is evaluated independently. Meanwhile, dependencies relationship does exist between the attributes of 'environment', 'economy' and 'society' during the selection of contractor that deliver SI. Therefore, there is a need for a paradigm shift from 'open' to close loop evaluation technique (system approach) contractor pre-evaluation process.

4.3: Action Research Strategy

An action research follows a characteristic cycle. Early in the cycle, an exploratory stance is applied. This is followed with the developed understanding of a problem. Plans are thereafter made for some form of intervention strategy. Denscombe (2010) considered action research strategy, also known to be contextual action research, as the most appropriate when purpose of inquiry is to solve a practical problem and produce guidelines for best practice.

Table 4-1: Three types of action research

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Source: Masters (1995)

Table 4.1 shows the dynamic nature action research methodology and its suitability in both qualitative and quantitative inquiries. Customarily, action research methodology is assumed to be a qualitative research. The illustration of three dimensions' action research by Master (1995) further endorses the technique as a flexible technique to solve social inquiry. Helskog (2014) justified action research as a scientific technique, as opposed to the claim by Somekh (2006) where action research was considered basically as a qualitative research methods of data collection are specific to research design. This claim was rebuffed by Denscombe (2010) and the argument holds that a choice of data collection abounds for research design.

4.3.1: Soft System Methodology (SSM)

SSM is a methodological process and a form of action research approach (Denscombe, 2010). Generally, action research methodology aims at solving a practical problem and produce guidelines in the management of change and best practice (Denscombe, 2010). The procedure is grounded on systemic philosophy, seeking to solve a practical problem and produce guidelines for best practice (Helskog, 2014; Denscombe, 2010). The ontological stance of the strategy allows constructivism of reality that can be validated based on objective view on benchmark for a best practice. Helskog (2014) further justified action research as a scientific technique. This study thereby benefited from triangulation.

SSM employs models to structure debate in which various conflicting interests and needs can be dissected and resolved among parties. Green (1999) recognised SSM as a responsive approach for structuring and solving multi-dimensional problems, characterised by ambiguity and conflicts among stakeholders. This concurred with the view of Male et al (2007) on the suitability of action research as an effective research design in value study in construction management. Since the development of SSM by Checkland and Scholes in 1970s, it has evolved, and successfully applied to the real-world problematic situations (Mehregan et al., 2012), such as educational project (Tajino et al., 2005), agriculture (Mills-Packo, et al., 1991) and urban development and physical planning (Nidumolu et al., 2006). SSM is identified as the most established ‘soft’ methodologies within UK value management practice (Green, 1999), capable to bring about compromised solutions.

Being a systemic methodology, it focuses on the interference in all components of sub-system. Facilitator and stakeholders can think and understand the problematic situation from different perspectives. The resultant effect is problems being solved through knowledge gained from the

situation, which in turn proffer solutions for improvement. Though origin of action research is traced back to late 1940s (Denscombe, 2010), the technique has evolved since the development of SSM by Checkland and Scholes in 1970s. It is identified as one of the three most established 'soft' methodologies within UK value management practice (Green, 1999) that is capable to bring about compromised solutions.

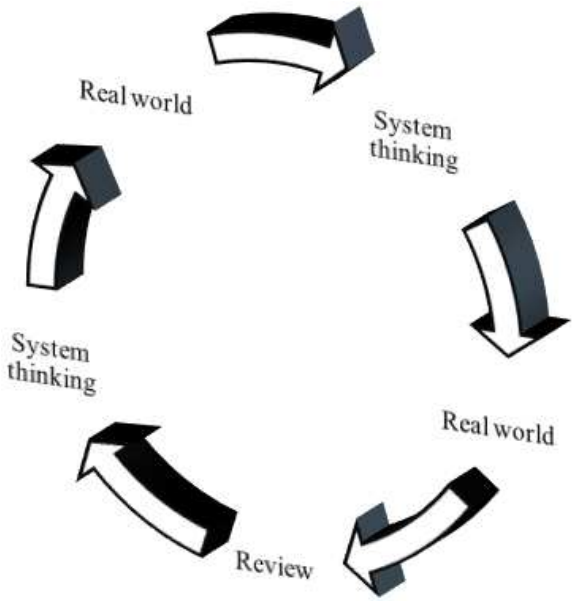

Figure 4-1: Closed loop of SSM
Source: Adapted from Checkland and Scholes (1990)

Checkland and Scholes (1990) illustrated SSM using phases and stages, as illustrated in Figure 4.1. These stages are the sum of activities that arise in 'real world' and 'systems thinking'. In the real world are the activities that can be influenced by the stakeholders. In contrast, systems thinking phase provides objective views about the real world, that is based on best practice.

4.3.1.1: Problem Situation

The starting point of the seven stages SSM methodology is the identification of a problematic situation for appropriate intervention. Initially, this may emanate from personal observation or contemporary events.

4.3.1.2: Problematic Situation Expressed

At this stage, better knowledge about the problematic situation is gained and these are expressed by answering 'What? How? Why? If questions. For instance, in a system that is plagued with improving GDP and abject poverty, one logical question out of curiosity is to explore what constitute opportunities in the economy? How well opportunities are optimised in key economic sector that can generate employment and stimulate productivity in broader economic sector? Why the current situation persists? Long-term implications of poverty on national development if no intervention measures are put in place? By doing so, better understandings of immediate and long-term implications of the problematic situation are gained. To express the situation under scrutiny in its richness, 'rich picture' is introduced as a supporting technique (Mehregan et al., 2012; The Open University, 2006; Checkland and Scholes, 1990). The rich picture is a graphical representation of relationship between elements that constitute a system under scrutiny. The richness of the picture is supported by extensive information obtained by the researcher. Data sources may include literature review, interviews, discussions and personal observations.

4.3.1.3: Root Definitions

Root definition is the first of the two activities in the 'system thinking'. The idea of system thinking is that system exists independently of human perception (Green, 1999). To make sense out of the situation in the real world, similar but functional systems are identified, and they are used as benchmark for best practice for a system under scrutiny.

4.4: Research Methodologies Applied for this Study

The research processes this study is presented in Figure 4.2.

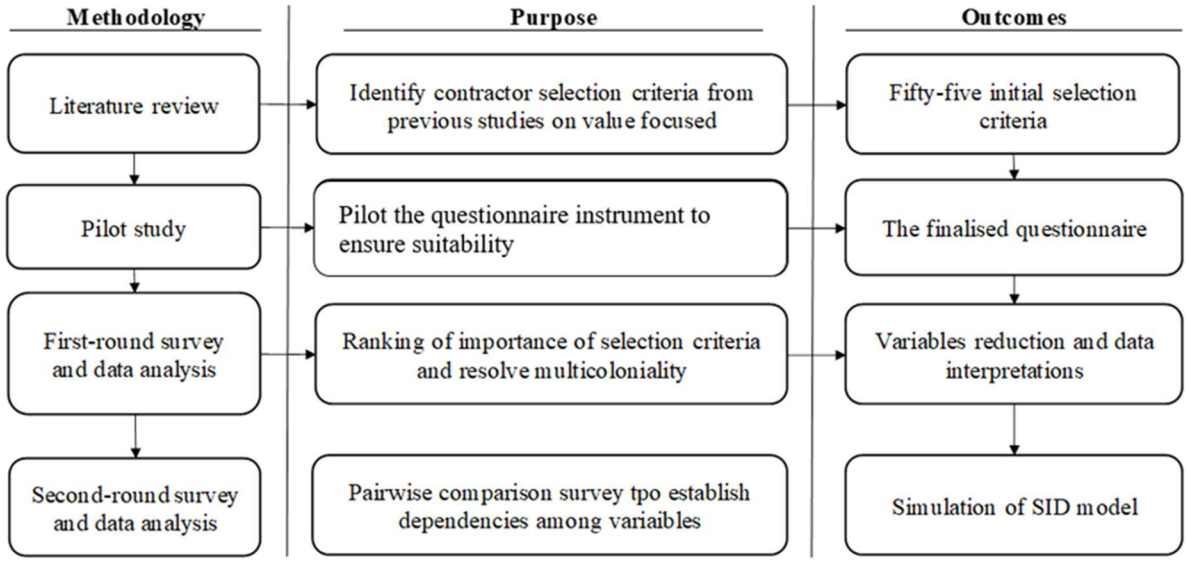

Figure 4-2: Research process

Source: Adapted from Yang et al. (2009)

4.4.1: Research Design

Soft System Methodology (SSM) was adopted in this study as methodological framework. The methodology allows for a 'loop', which enhances continual improvement of a process. The first section involves an explicit analysis of the current infrastructure delivery in Nigeria and value-added implications. This is followed with benchmark formation based on lessons learnt from similar bur effective and sustainable systems. Following development of benchmark mark for best practice, opinions of the experts were sort on the current case study. Analysis of data and discussion of findings followed. The results further informed on what-to-do to enhanced better and more sustainable infrastructure delivery.

SSM was considered as the most appropriate technique for structuring contractors' selection for sustainable infrastructure in Nigeria. The methodology presented a mechanism, which helped to make a right judgement on the existing selection practice based on lesson learned from a similar but functional system that deliver best value.

4.5: Methods Applied for Primary Data Collection

Primary sources of data included web-based questionnaire, pairwise comparison survey and structured interview, targeting construction experts in Nigeria. This study further benefited from the feedback from peer reviews from conference proceedings and reviewers' feedback on the published journals (see related publications in appendix 1).

A positivism epistemological stance was adopted for identifying contractor's selection criteria. The idea was to first obtain opinions on wider experts on the importance of the 55 selection criteria identified from the literature towards predicting are contractors that would deliver sustainable infrastructure. The criteria number was reduced through factor analysis to make it suitable for the implementation of pairwise comparison survey. It is the feedback obtained at this level that was used for the final evaluation of contractors.

4.6: Pilot Study for Questionnaire

Following the draft of the questionnaire for this study, pilot study was conducted, using a convenience sampling technique (Denscombe, 2010). Key objectives of the pilot survey were to examine the clarity of language, appropriateness and logic of questions, degree of depth, and layout and user friendliness of the whole questionnaire (Enshassi et al., 2013; Oyedele, 2013). The pilot survey involved 15 construction experts, with average of 9 years of work experience.

Of the 15 pilot questionnaires sent to the selected experts, 9 were returned indicating a response rate of 60%. The feedbacks were encouraging. Respondents commended that the broadness of initial 59 criteria met their expectations on in-depth list of criteria for sustainable contractor selection. However, the summary of the feedback suggested few questions to be reworded for creation of simple and easy to complete questionnaire. Furthermore, 4 criteria were advised to be removed as they were closely related to others.

Following the modification of the questionnaire in response to the feedback above, a decision to implement web-based survey was made.

4.7: Web-based Questionnaire Survey

The choice of web-based questionnaire survey as data collection instrument was influenced by its cost and time effectiveness, as well as its convenience and "paperless" approach. The technique is cost effective and facilitates the covering of many respondents and automated data entry (Diaz-Sarachaga et al., 2017; Andrews et al. 2003; Roztocki and Morgan, 2002).

A study of this nature could benefit from qualitative data, and this prompted the initial consideration for Delphi technique as data collection instrument. Delphi is a survey technique that is enhancing popularity in participatory research in construction management. It is a systematic approach, focusing on experts' opinions on decision making process. The technique alters the established practice, by allowing an extensive time to resolve the problem and achieve a consensus decision (Sourani and Sohail, 2015; Chan et al., 2001). The prolonged period of iteration among unanimous members of panel is to fine-tune critical decision factors. Philosophical considerations in Delphi have been found to be either qualitative, quantitative or mixed approach to data collection (Sourani and Sohail, 2015).

The major different between Delphi and questionnaire is the repetitive rounds of iteration with the participants. Multiple phases of questionnaire administration are engaged and reviewed until consensus results are obtained (Sourani and Sohail, 2015). Delphi is therefore, considered as a very sensitive technique, whose success requires absolute commitment of the same set of respondents that started the study. Also, it is most utilised when little is known about the inquiry.

Data obtained from direct interaction with population sample either in a single or multiple phases of seminars can be rich and of high quality. However, during consultation with the Director of Study, issues were raised regarding safety during data collection exercise, costs, time that would be spent for data collection and commitment of respondents when the data collection requires multiple stages feedback. The issues regarding ethical considerations being compromised were also reviewed.

Following the above, it was agreed that web-based questionnaire survey was the most cost effective and a reliable data collection tool for the study. This does not negate the fact that the choice of web-based survey for positivist research has its own shortcomings, which were envisaged in this study as validity and operationalisation of construct (how factors are represented and measured) (Enshassi et al., 2013). The Kaiser-Meyer-Oikin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity tests were conducted to verify the suitability of the data set for FA (Asadzadeh et al. 2015; Doloi, 2009; Yang et al., 2009; Oyedele and Tham, 2007).

4.7.1: Questionnaire Structure

A four-section questionnaire was developed. Section one contained the cover letter that explained respondents what the goal of the survey is. The second section comprised of general background information of respondent (see appendix 1 and 2). It was aimed at gaining information on discipline, industrial experience, field of work, education level, and current position, nature of industry and awareness respondent to BOT contract. Section three of the questionnaire obtained data that were critical to hypothesis testing. Benefits of construction, as identified by Babatunde and Low (2013), were summarised in four categories: 'Higher quality construction', 'Wider economic benefits', 'Multiplier effects', and 'Direct effects' (see appendix). Respondents were asked to rate their agreement on these attributes towards support for social economic development. Respondents' level of agreement was obtained using a five-point Likert scale, where 5 represents 'strongly agree' and 1 represents 'strongly disagree'. Section four sought to obtain feedback on ranking of contractor selection criteria. A total of fifty-five relevant selection criteria identified from literature were applied. Respondents were asked to rank importance of the criteria on a five-point Likert scale, where 5 represent 'very important' and 1 represents 'not important'. Although Likert scale assumes that the scale between each choice is equidistant, it is a convenient and easy scale to use, and it is often applied in related studies in the literature.

4.8: Sample Population and Response Rate

The sample frame used for the web-based questionnaire comprised of architects, engineers, quantity surveyors and construction managers in Nigeria. The web-based survey links was posted on the website associated with these professional bodies in Nigeria: Nigerian Institute of Architects (NIA); Nigeria Institution of Civil Engineers (NSE); Nigerian Institute of Quantity Surveyors (NIQS); and Nigerian Institute of Builders (NIOB). Due to the missing contact details of the professional members on their website, it was not practicable to apply probability sampling strategy. Snowball sampling was thus employed (Brammer and Walker, 2011) for data collection. It is non-probability sampling technique where surveyed population help to acquire more respondents through their networking. The technique is found to be invaluable in reaching hidden population.

A total of 143 survey feedbacks were obtained from the questionnaire administered for this study. To give a comparison, in a similar study that adopted non-probabilistic surveys (Gunduz and Yahya, 2015), 111 responses were received for a study seeking global responses from targeted different countries and companies. In a web survey conducted by Oladinrin and Ho (2015), targeting global population, 115 responses were obtained for over 5-month period.

Denscombe (2010) argues that there is no hard rule on the constitution of an acceptable response rate for a questionnaire survey. As a guide, Denscombe (2010) postulated questions that helped in the evaluation of an acceptable response rate:

1) *Is the level of response reasonable and in line with comparable survey?*
2) *Have appropriate measures been taken to minimise non-response rates?*
3) *Do the non-responses differ in any systematic and relevant fashion from those who have responded?*

To achieve maximise response rate in this study measures employed in this study were as follow:

1) *Regular reminder on the completion of the questionnaire was posted on the target professional bodies (NIA, NSE, NIQS, and NIOB).*
2) *Targets were reminded of completion date of questionnaire, stressing how important their response would contribute to the success of the study*
3) *Follow-up reminders and deadline for the questionnaire where contact details were available*
4) *Option of access to the final research report on completion was offered to respondents*

To further facilitate the 'snowball' process in data collection, the attached cover letter (see appendix 2) encouraged respondents to share the survey links with their colleagues.

To validate data that was obtained, a follow-up structured interview was conducted with 3 construction experts that engaged directly with PPP contract to verify the ranking of the selection criteria.

4.9: Factor Analysis

Factor analysis (FA) is a multivariate statistical approach that was originated through the work of Pearson and Spearman over a century ago (Williams et al., 2010). Though the technique is historically used in psychology and education (Williams et al. 2010), its general acceptance and application in social science research has been overwhelming (see Oladinrin and Ho, 2015; Oyedele, 2013; Doloi, 2009; Yang et al. 2009; Oyedele and Tham, 2007). Factor analysis has multiple uses (Williams et al., 2010).

The three applications of factor analysis that are directly applied in this study are:

1) *Reduction of large number of variables to a set of variables that are also referred as factors*
2) *Establishment of underlying dimensions between measured variables and latent constructs, which facilitate the formation and refinement of theory*
3) *Provision of construct validity evidence of self-reporting scales (Williams et al.,2010)*

There are two classes of FA, and they are Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) (Asadzadeh et al. 2015; Williams et al., 2010). In the EFA, as the name suggests, researcher has no clear idea of the number or nature of variables that will be derived. CFA, on the other hand is an approach used by the research to test a proposed theory with established factors (Williams et al., 2010). By its nature, EFA is associated with quantitative research.

4.10: Exploratory Factor Analysis (EFA) Methodology

The main purpose of the application of EFA in this study is to facilitate the implementation of the final decision-making process on contractor selection, which satisfies key applications of the techniques. For the implementation of EFA, multi-steps are involved (Asadzadeh et al. 2015; Oyedele and Tham, 2007). The procedure is simplified to 5-step by Williams et al. (2010), as presented in Figure 4.3.

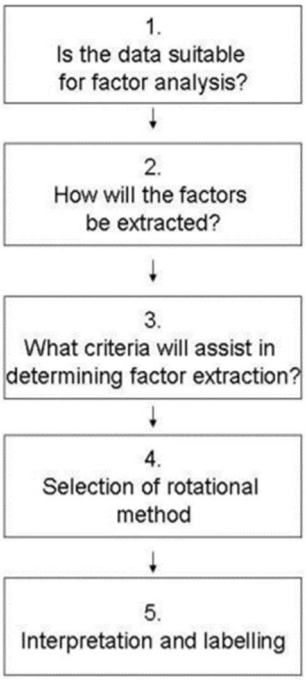

Figure 4-3 Step Exploratory Factor Analysis Protocol
Source: Williams et al. (2010)

4.11: Is the Data Suitable for Factor Analysis?

Approaches to test the suitability of data set for factor analysis include the following: sample size, multicollinearity, and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Barlett's test of sphericity. From extant literature, it is observed that varied opinions and several guiding rules are applicable to sample size selection in FA application, which by its nature is problem dependent (Williams et al., 2010). Though 50 samples or more are suggested to be adequate for factor analysis Williams (et al., 2010), samples of studies on ANP with the integration of factor analysis (Asadzadeh et al., 2015) and related construction research (Yang et al., 2009; Oyedele and Tham, 2007) were not strict about sample sizes.

The Kaiser-Meyer-Oikin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity tests are consistently used to test the suitability of data for EFA in the literature (see Asadzadeh et al. 2015; Williams et al., 2010; Doloi, 2009; Yang et al., 2009; Oyedele and Tham, 2007). The KMO is the ratio of the squared correlation between variables to the squared partial correlation between variables. The KMO index ranges from 0 and 1. It implies that a value that is close to 1 indicates that patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable factors. 0.5 Index is generally considered suitable for FA (Oladinrin and Ho, 2015; Oyedele, 2013; Williams et al., 2010; Yang et al., 2009). The Bartlett's Test of Sphericity should be significant ($p<.05$) for FA to be suitable (Williams et al., 2010; Oyedele and Tham, 2007).

4.11.1: How will Factors be Extracted?

Options for factors extraction include principal components analysis (PCA), principal axis factoring (PAF), image factoring, maximum likelihood, alpha factoring and canonical (Williams et al., 2010). PCA and PAF are most common applied methods of factor extraction in the literature though there is insignificant practical difference between PCA and PAF, PCA is often used to generate preliminary solutions in EFA (Oladinrin and Ho, 2015; Williams et al., 2010). The same trend is observed in construction related studies (see Asadzadeh et al., 2015; Oladinrin and Ho, 2015; Doloi, 2009; Oyedele and Tham, 2007) to reduce the highly correlated contractor selection criteria into a smaller number of key factors.

4.11.2: What criteria will Assist in Determining Factor Extraction?

The goal of data extraction is to reduce large variables sets to smaller variables sets. Williams et al. (2010) suggested that simultaneous use of multiple decision rules is appropriate and desirable to determine factor extraction. By doing so, extracted factors can be validated based on the outcome of multiple extraction criteria. Available extraction approaches (Williams et al., 2010; Doloi, 2009) include: the cumulative percentage of variance extracted, Kaiser's criteria (eigenvalue >1 rule), and the Scree Test.

There are no generalised acceptable rules on criteria for factor extraction. For instance, for cumulative % of variance and eigen value, it is suggested that natural science research factor extraction should stop when at least 95% of the variance is explained, whereas, in humanities, extraction is stopped between 50 -60% (Williams et al., 2010).

4.12: Analytic Network Process

Most of the AHP assumptions are unjustifiable in a complex decision situation. Cheng and Li (2004) observed that most studies that applied AHP for the selection of contractor for construction projects assumed that criteria were independent of each other. Such assumption cannot hold in a real-life scenario, especially with the 'pluralistic' nature of construction clients. Furthermore, growing popularity of innovative procurement strategies require an effective framework for the evaluation of influences among critical selection criteria to forecast project performance. For instance, modulus operandi in public procurement in DC that favours PPP strategy is a typical problematic decision-making process for many reasons:

1) *Redefinition of obligations of parties and usage of stakeholders rather than project client*
2) *Application of innovative procurement strategy that support risk sharing*
3) *Complexity of project specific objectives, taken considerations of tangibles and intangibles*
4) *Management of conflicting interests*

Analytic Network Process (ANP) is a generalisation of AHP used in multi-criteria decision analysis, where AHP is extended to cases of dependence and feedback. As highlighted earlier, AHP is a top-bottom structured decision problem. Saaty (2013) defined ANP as:

> *"a multi-criteria theory of measurement used to derive relative priority scales of absolute numbers from individual judgments (or from actual measurements normalized to a relative form) that also belong to a fundamental scale of absolute numbers"*

Saaty (2013) developed ANP to resolve the limitations of AHP in solving complex decision problems. The uniqueness of the ANP is the shift from 'unidirectional' to 'close-loop' approach in the structure of problematic decisions (Neubert, 2015; Saaty, 2013). Gaining knowledge of systemic nature of selection process in diverse field of studies has contributed to greater acceptance of ANP (see Neumüller et al., 2015; Aragones-Beltra et al.,2014; Cannemi et al.,2014; Lee et al., 2013; Giner-Santonja et al., 2012; Aragones-Beltra et al., 2010; Chang, 2009; Bayazit (2006; Cheng and Li, 2004). Key benefits of ANP include:

i. *the provision a systematic approach to set priorities and trade-off among criteria*
ii. *the ability to measure tangible and intangible criteria in the decision model*
iii. *the technique is a practical and an intuitive approach that can easily be adopted by decision makers in public domain*

Presented in Table 4.1 is the review of literature on the application of ANP in solving complex decision problems.

Table 4-1: Literature review on the application of ANP

Project	**Author (s)**
Examination of LEED-certified building operational performance	Deniz (2017)
Election of green marketable products	Neubert (2015
Integrating three-dimensional sustainability in distribution centre selection: the process analysis method-based analytic network process	Neumüller et al. (2015)
Selection of solar-thermal power plant investment projects	Aragones-Beltra et al. (2014)
A support tool for policy making on renewable energy development	Cannemi et al. (2014)
Ranking of critical success factors of waterfront development	Lee et al (2013)
Assessment of best available techniques	Giner-Santonja et al. (2012)
Sitting of a municipal solid waste plant in the metropolitan area	Aragones-Beltra et al. (2010)
Selection of a televised sports-casters for Olympic Games	Chang (2009)
Risks assessment in commercial real estate development	Khumpaisal (2009)
Selection of lean manufacturing systems	Kodali (2009)
Vendor selection decisions	Bayazit (2006)
Contractor selection using the analytic network process	Cheng and Li (2004)

Complexities often arise in the implementation of the ANP due to numerous variables that are often considered for comparison matrix. A study by Bayazit (2006) concluded that the application of many variables during pairwise comparison survey often results in low response rate.

There is growing application of ANP contractor selection and related decision making in construction. Meanwhile, questionnaire for ANP (known as pairwise comparative survey) often generate voluminous matrixes (see appendix). From the available literature, low response rate reported during pairwise comparative survey (a structure for ANP questionnaire) is attributed to too many questions. It is suggested that application of lesser variables during the matrix for the survey encourage and facilitate better participation of respondents and subsequent high response rate (Oladinrin and Ho, 2015; Doloi, 2009; Yang et al., 2009).

Different strategies have been tested in the literature to achieve improved response rate in pairwise comparison survey. In a study conducted by Bayazit (2006) for vendor selection, only ten most important attributes were applied for matrix formation. In another study, Giner-Santonja et al. (2012) considered seven criteria for the assessment of best available techniques.

Various data reduction techniques are being postulated by social researchers to arrive at factors. In a research conducted by Chang (2009) for the selection of televised sports-casters for Olympic Games, 12 criteria that were mentioned more than 30 times by respondents were applied. Meanwhile, number of studies (Oladinrin and Ho, 2015; Doloi, 2009; Yang et al., 2009; Oyedele and Tham, 2007) considered FA as a reliable factor reduction technique. FA is being scientifically proven and popular among social researchers. These justify the integration of FA to ANP methodology in this study.

4.12.1: The ANP Model

The purpose of ANP in this study is for data synthesis during contractor's evaluation process. It is a shift from a linear to systemic approach during evaluation process. More importantly, ANP is integrated to the proposed SID. Overall, the decision model is a network of clusters. Cluster is a group of nodes with a lurking theme. Links are connection between nodes. Figure 4.4 illustrates the relationship between AHP and ANP.

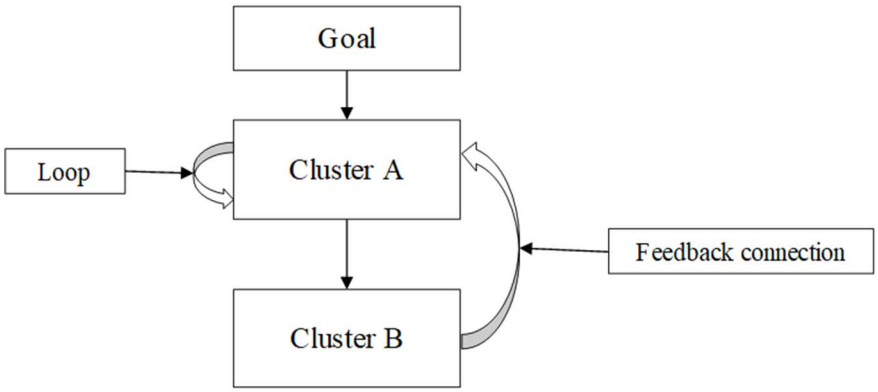

Figure 4-4: Illustration of ANP as a generalisation of AHP

The arrow from the goal to Cluster A means that each criterion must be paired compared for their importance with respect to the goal. Likewise, the arrow that connect each criterion to Cluster B means that the alternatives are paired compared as to which is more preferred for that criterion.

The typical connections that transform AHP to ANP are inner dependence, outer dependence and feedback connections. The decision network is designed after the relationships among nodes have been developed. A feedback connection makes it possible to consider weighing of criteria from two possible scenarios. It is a demonstration of outer connection and in a reverse version. For instance, the ranking of alternatives might not only depend on the weight of criteria, rather given alternative can influence the weighting of criteria (Saaty, 2013). A feedback connection thereby, improves priorities derived from the judgements, thereby making the prediction in real life complex decision more accurate and realistic.

4.12.2: Establishment of Priorities in ANP

Saaty (2008) advanced two ways to learn about an idea. Firstly, a subject is studied in its richness of its attributes. The second way is to study the entity relative to other similar entities and relate them by making comparisons. In a real-world situation, measurement is commonly taken by using a physical scale with unit on it. The purpose is to gain knowledge about the subject or the phenomenon. Final decision is arrived at and it is based on the interpretation of the results as compared to the expectations (Saaty, 2013).

The judgement of comparisons is intrinsic in the operations of human brain (Saaty, 2013). The comparison matrix in the ANP captures the relative dominance of one node over another with respect to a control criterion. In making judgement, experts' interventions are required, and these are associated with their feelings, feelings with intensities, intensities with numbers, numbers with a fundamental scale of priority (Cheng and Li, 2004; Saaty, 2004).

To avoid irrational assignment of scores by decision makers, Saaty (1990) has postulated a 9-point priority scale for obtaining judgement matrix as shown in Table 4.2.

Table 4-2: The fundamental scale

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgement slightly favour one activity over another
5	Essential or strong importance	Experience and judgement strongly favour one activity over another
7	Very strong importance	An activity is favoured, and its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgements	When compromise in needed
Reciprocals	If activity *i* has one of the above numbers assigned to it when compare with activity *j*, then j has the reciprocal value when compared with *i*	

Source: Adapted from Saaty (1990)

The scale (in Table 4.2) highlights the fundamental scale for deriving ratio scale priorities. Opinion of a decision maker is represented in a verbal judgement with their corresponding measurement. The corresponding measurements are used to derive ratio scale priorities for the distribution of among criteria and clusters in the decision model.

The procedure for pair comparison requires experts who compare two sub cluster's elements with respect to their respective cluster's element (Cheng and Li, 2004). The children's nodes are paired compared with respect to the parent node for dominance. In comparison of criteria 'X' and 'Y', then '1' denotes that 'X' and 'Y' are of equal important. 3 indicates that X is moderately more important than Y. 5 indicates that X is strongly more important than Y. 7 indicates that X is very strongly more important than Y. Finally, 9 indicates that X is extremely more important than Y.

It is pertinent that the structure of the comparison question is consistent throughout the judgement process. Decision maker must keep in mind whether the influence is flowing from the parent node to children's nodes being compared, or in reverse order (Saaty, 2013). On this note, two mode of questionnaire structure were suggested:

Given a parent element and comparing elements A and B under it, which element has greater influence on the parent element?

Given a parent element and comparing elements A and B, which element is influenced more by the parent element?

Table 4.3 presents a guideline for the number of comparisons to compute in each network.

Table 4-3: Guidelines for the number of comparisons

No of elements	2	3	4	5	6	7	8	n
No of comparisons	1	3	6	10	15	21	28	$\frac{n(n-1)}{2}$

Pairwise comparison is based on a construct of a matrix where the same sets of factors are arranged in rows and columns. The matrix table for paired comparisons is divided into two equal triangles. While the diagonal is a constant 1, the actual pair comparison matrixes are input to the upper triangle matrix. Reciprocals are input into the lower triangle to complete the matrix. By convention, if *'i'* is more important than *'j'*, a number ranging from 1 – 9 is entered. If the outcome is a reverse, then a reciprocal of a number ranging from 1 – 9 is entered. Let element of row = *i* and column = *j* of the matrix. Let *aij* be the relative dominance of Ai over *Aj* in the paired comparisons process. If *aij* is the element of row i column j of the matrix, then the lower diagonal is completed by the reciprocal pairwise denoted by

$$a_{ji} = \frac{1}{a_{ij}} \quad \text{..... (i)}$$

For *n* criteria, using Saaty's fundamental scale, to compute pairwise comparison for matrix A, based on the judgement a_{ij}, where $a_{ji} = 1/a_{ij}$

Table 4-4: A pairwise comparison decision matrix (A)

		A_j				
			A_1	A_2	-	A_n
A =	A_i	A_1	C_1/C_1	C_1/C_2	-	C_1/C_n
		A_2	C_2/C_1	C_2/C_2	-	-
		-	-	-	-	-
		-	-	-	-	
		A_n	C_n/C_1	-	-	C_n/C_n

From matrix A (Table 4.4), judgement a_{ij} $(C_1/C_1$-------- $C_1/C_n)$ are single number drawn from fundamental scale, their reciprocal is input for a_{ji} (Saaty, 2008).

Let denotes criteria by $A_1, A_2, \ldots A_0$

Let denotes weight by $C_1, C_2, \ldots C_n$

The diagonal elements of the matrix are always 1 (a diagonal line between the upper and the lower triangle). The actual judgement of criteria is filled in the upper triangle.

If a_{ij}, is the element of ^{i} column ^{j} of the matrix, then the lower diagonal is filled using $a_{ji}=1/a_{ij}$

Saaty (2013) outlined 12 steps in the ANP methodology. In earlier studies on the principle and application of ANP, the process had been modified and simplified into few steps, and more users' friendly in application (see Bayazit, 2006 and Cheng and Li, 2004).

The methodology of the ANP in this study is summarised as follow:

i. *Define the control criterion*
ii. *Determine the criteria for decision network*
iii. *Apply FA to reduce the criteria to manageable quantity by solving multicollinearity issues in the survey data*
iv. *Derive lurking dimensions for criteria that are clustered by FA*
v. *Determine the influences that exist between criteria within the same cluster and criteria between different clusters*
vi. *Design a pairwise comparison questionnaire*
vii. *Conduct pairwise comparison survey to obtain data to develop unweighted supermatrix*
viii. *Conduct pairwise comparison for cluster priorities with respect to the goal to obtain data to make matrix column stochastic (i.e., weighted supermatrix)*
ix. *Check for inconsistency ratio in each of the respondent data (CR must not be greater than 1)*
x. *Aggregate respondents' data with geometric mean*
xi. *Input overall data to Super Decisions Software that implement ANP for data simulation*
xii. *to derive limit matrix where global priority is established*

4.12.2.1: Eigenvectors

The concept of priority is important in decision making. Also, of significant importance is how priorities are derived (Saaty, 2003). Saaty (2003) argued that ratio scale obtained through normalisation is the only logical way to to represent priorities derived from pairwise comparison matrix. The idea is to improve the validity of the priority vector by transforming a given reciprocal judgement matrix to a near consistent matrix (see appendix 2 for illustration).

4.12.2.2: Inconsistency in Weight Assignment

Due to human factor, such as emotion and subjective views, absolute consistency is not guaranteed in all judgements. Saaty (2013) stressed that; even the most knowledgeable person in a specialised field cannot be consistency always in their judgement due to the dynamic nature of the world that brings about new idea about a subject. Saaty (2004) earlier argued that a modicum of inconsistency in judgement is very useful in decision process as it indicates human ability to learn new things that improve and even change outstanding of an event.

The reliability of judgements in the pairwise comparisons is determined by their consistency ratio (CR) (Saaty, 2004). As a guideline, for a degree of inconsistency in a judgement, a threshold level of 0.05 for 3-by-3 matrix; 0.08 for 4-by-4 matrix; and 0.1 for all other matrices are suggested (Cheng and Li, 2004). To compute CR for a matrix 'A', applied formula is:

$$\ldots\ldots\ldots\ldots C.R.(A) = \frac{C.I.(A)}{R.I.}, \qquad \text{(ii)}$$

$$C.R.(A) = \frac{CJ(A)}{R.I.} \text{ (Insert > Equation > New Equation)} \qquad (3)$$

…. where CR = Consistency Ratio, CI = Consistency Index, RI = Random Consistency Index (see appendix 2 for illustration)

To compute a CI of matrix A:

…… $CI = \frac{\lambda_{max} - n}{n - 1}$, (iii)

….where [λmax] = Principal Eigen vector, n = number of criteria

Principal Eigen vector [λmax] is the total value obtained from the the product of eVector in normalised matrix with the corresponding 'sum' in comparison matrix.

Random Index (RI) is obtained from random reciprocal matrix using Saaty's fundermental scale (see Table 4.5 for a guideline).

Table 4-5: Random consistency index

N	1	2	3	4	5	6	7	8	9
RCI or RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Source: Adapted from Saaty (2008)

Therefore, CI $\{= \frac{\lambda_{max} - n}{n - 1}\}$ (see appendix 2 for illustration on CR computation)

4.12.3: The Supermatrices of the ANP

The formation of supermatrix starts when all clusters of the network and nodes within them are arranged horizontally and vertically. All nodes of the network are fully represented, and none zero elements of the matrix represent a connection and weight from one node to another of the network. Nodes of the network are paired compared as long there is a relationship between them. Relative importance weights (eigenvectors) obtained are then placed in the appropriate column of the supermatrix, resulting in unweighted supermatrix.

4.12.3.1: Stochasticity of a Supermatrix

ANP is a collection of matrices (Saaty, 2013). Each column of the supermatrix consists of several eigenvectors that were initially being normalised and sum to one (Saaty, 2013). Therefore, the entire columns sum to an integer greater than one (Saaty, 1999). Before taking the limit, ANP matrices must first be transformed to a column stochastic or simply stochastic matrix (Saaty, 2013). To reduce supermatrix to a matrix (Saaty, 1999), the influence of the clusters or component on each other with respect to the control criterion is first determined (Saaty, 2013; Gencer and Gurpinar, 2007; Saaty, 1999). A cluster is defined as a block determined by a cluster's name at the rows and a cluster's name at the columns in a supermatrix. After clusters' priorities have been established, elements in each cluster are multiplied by the cluster priority (Saaty, 1999). The new matrix, weighted supermatrix, adjusts the relative importance weights in discrete matrices to form overall matrix (Cheng and Li, 2004). In a case where the network is comprised of only two clusters, component weighting cannot be completed. In such a case, unweighted and weighted supermatrices are same.

4.12.3.2: Limit Matrix

The supermatrix is at a stable state when row values converge to the same value for each column of the matrix (Saaty, 2013; Gencer and Gurpinar, 2007). To achieve this, the weighted supermatrix is raised to powers by multiply by itself. The limit matrix is reached when the column of numbers is the same for every column and the matrix multiplication can be halted.

4.13: Super Decisions Software

The software was developed essentially for the implementation of ANP. The ribbon on the work template allows for decision model creation and input of pairwise comparison data. During data stimulation, Super Decisions software confirms the consistency ratio to ascertain

the suitability of data for further analysis, used to compute the final priorities of the alternatives being weighted.

4.14: Multiple Regression

Multiple regression is an extension of simple linear regression. It is used to understand the relationship between multiple independent (predictor) variables and a dependent (criterion) variable based on the value of two or more. For simplicity, Multiple Regression is used to predict the value of a variable (called dependent) based on the value of two or more variables, called predictor (independent) variables.

Regression analysis establishes a mathematical relationship between dependent variable (Y) and an independent variable (X) (Adair and Mcgreal, 1988). In a simple linear regression, a single independent variable is used to predict the value of dependent variable (i.e. the outcome, target, or criterion variable).

For a simple regression analysis:

$$Y = B_0 + B_1X \quad \text{(iv)}$$

Where $\mathbf{B_0}$ is the regression constant

$\mathbf{B_1}$ is the regression coefficient of value rating for the independent variable

From the known value for independent value (X), the value of the dependent variable (Y) can be predicted.

In a real like situation, such as selection criteria for contractor that support SID, there are several interacting factors which can determine the value of established dependent variable. In such a case, simple regression model will be extended to deal with multiple independent variables, which is multiple regression analysis. The technique measures how the value of dependent variable (Y) depends upon the established set of independent variables (X).

For multiple regression analysis, with each of the independent variables (X_1 – Xn) having a value rating (B_1 – Bn) (Adair and Mcgreal, 1988):

$$Y = B_0 + B_1X_1 + B_nX_n \qquad (v)$$

4.15: Model Validation

One of the ways a scientific theory can be validated is to show the predicted results by the theory are like known results (Whitaker, 2007). Model validation is the process of assessing the degree to which the model effectively performs what is designed for. Validation is very critical part of decision model development. It increases the confidence in the model and make is worthwhile. Validation depends on the guiding principles and the process of empirical verification (Whitaker, 2007). These two factors are considered critical while establishing theory in any related knowledge.

Gass (1983) identified key areas where experts' opinions are sorted during validation process, which include 'completeness', 'accuracy and precision', 'comprehensibility' and 'cost effectiveness'.

1) *Completeness: This investigates the inclusion of the all-important selection criteria in the model*
2) *Accuracy and precision: This focus on the ability of the model to predict contractor that deliver sustainable infrastructure*
3) *Comprehensibility: this deals with the simplicity and user friendly of the model*
4) *Cost effectiveness: This examines the cost-benefit analysis of the model. It considers the correlation between the implementation of the model and the cost implications*

4.15.1: Sensitivity Analysis

Sensitivity analysis or what if analysis is normally conducted in data synthesis to find out what will happen when there are slight changes in data input. The main goal of the sensitivity is to determine how different values of the independent variables will impact the dependent variable under hypothetic assumptions. Sensitivity analysis is often conducted in MCDM techniques as it may hold a useful insight to the alternatives being described based on a set of criteria. The approach involves observation on relative impacts of slight modification of elements of the network on the overall outcome. The usefulness of the analysis is to inform on key criteria that require special attention due to higher achievement being achieved from a slight improvement. Decision makers can gain better insight and swiftly make modifications where necessary.

4.16: Testing the Suitability of Data for Factor Analysis

4.16.1: Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity

Prior to the extraction of factors, the Kaiser-Meyer-Oikin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity tests were carried out to scrutinise the sampling suitability.

The KMO measure of sampling adequacy and Bartlett's test of sphericity are commonly used to test for suitability of data for factor analysis in construction management studies (Asadzadeh et al. 2015; Doloi, 2009; Yang et al., 2009; Oyedele and Tham, 2007). A recommended minimum value for KMO (0.50) (Oladinrin and Ho, 2015; Oyedele, 2013; Yang et al., 2009) was applied. The Barlett's Test of Spherity should be significant: $p<.05$, for factor analysis to be suitable (Williams et al., 2010).

4.16.2: Multicollinearity

One of the major challenges in survey data, as evident in this study, is multicollinearity. Multicollinearity exists when there is strong linear relationship among the predictor variables, i.e. correlation between two or more variables. This implies that variables are replica of them, and as such, make regression coefficients unstable and unreliable for prediction (Katrutsa and Strijov, 2017).

Among the 55 relevant criteria established in this study, there was an evidence of significant correlation among predictor variables based on EFA correlation matrix. Furthermore, the determinate of the correlation matrix being 4.86E-006 (which is less than 0.00001) also strengthens the evidence and problem of multicollinearity in the dataset. To resolve this issue,

the iteration process was employed. The iteration process continues until non-significant linearly related variables are achieved in the model. The extraction rules and approaches applied were Kaiser's criteria (eigenvalue >1), the Scree test and the cumulative percent of variance extracted (Williams et al., 2010; Doloi, 2009).

4.16.3: Factor Reduction

From the literature review on selection criteria for contractor selection, 55 criteria were deduced, and ranked by their importance by 143 questionnaire respondents.

To generate data for the ANP, pairwise comparison survey was conducted. The larger the number of applied variables normally has a multiplier effect on the volume of responses that are required during survey. For instance, if 5 criteria are considered for pairwise comparison survey:

Applying the formula- $\frac{n(n-1)}{2}$, where 'n' is the number of criteria, number of comparison question to be asked is (5 x 4)/2 = 10.

For an effective application of the ANP methodology, large number of criteria must therefore first be reduced to smaller set of variables. Also, the underlying dimensions between measured variables and latent constructs must be established. Figure 4.5 shows data extraction process.

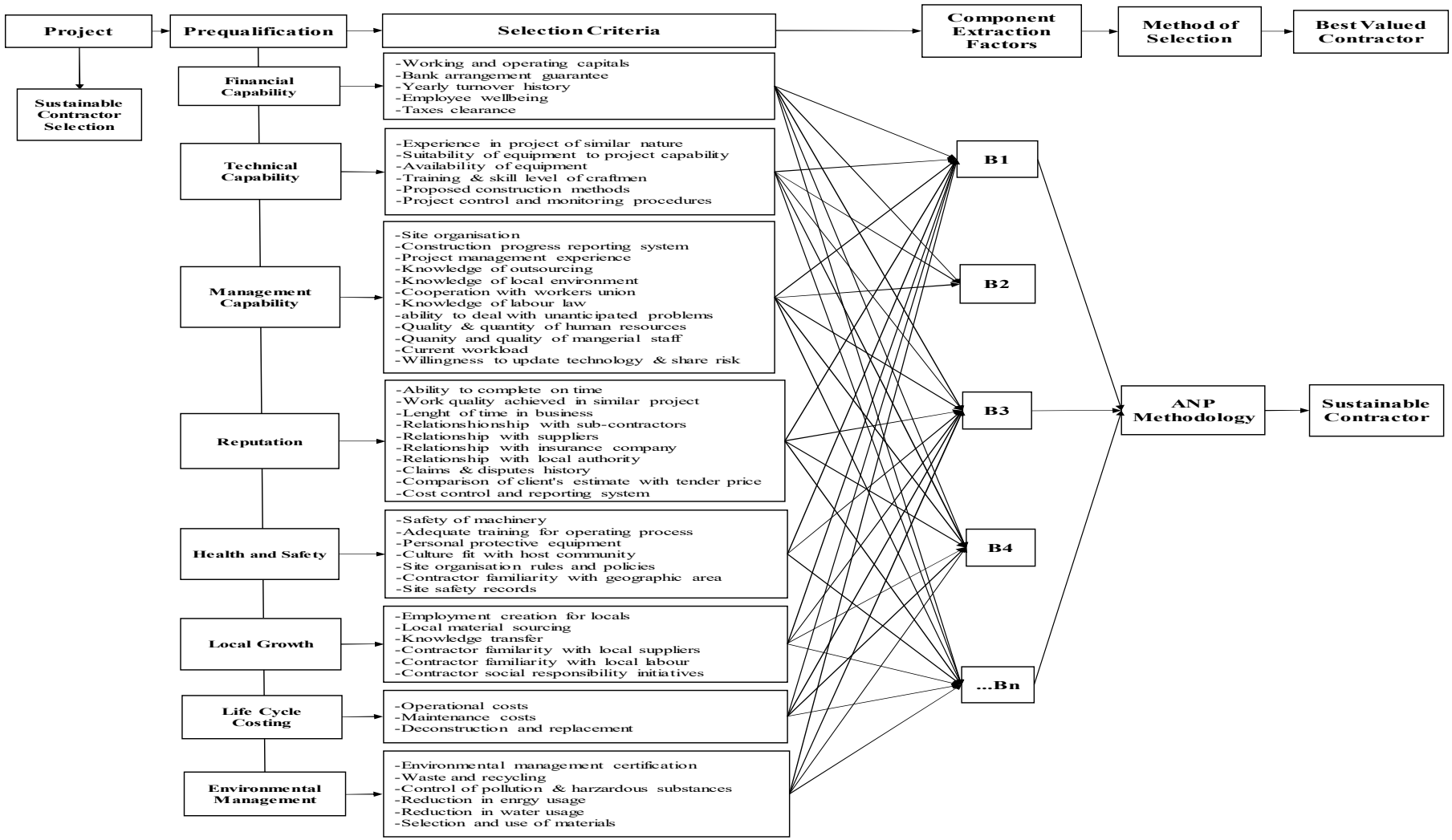

Figure 4-5: Data extraction process

4.17: Contractors' Evaluation: Implementation of ANP

The key research objective was to develop a novel framework that could be used during pre-qualification stages for contractors involved in the delivery of sustainable PPP projects. The proposed framework (SID model) is presented in the later section of this Chapter. At the deductive phase of the model is the integration of ANP, which aids the prediction of most potential contractor that would deliver sustainable infrastructure.

The deduction process began with the treatment of the questionnaire data from the previous section. By applying extraction method, varimax and Kaiser Normalisation as rotation method, these criteria were grouped to 5 components, based on their latent construct (Ikediashi and Okwuashi, 2015). The final criteria components are shown in Figure 4.6.

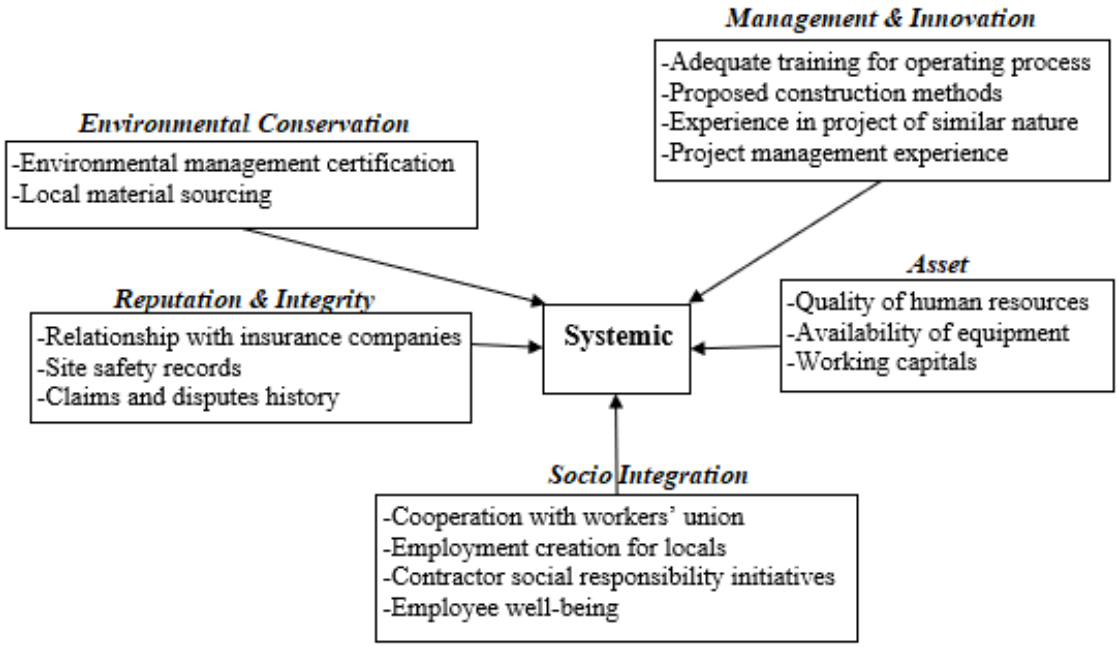

Figure 4-6: Conceptual Framework for the Criteria of Pre-evaluation of Contractors

The next step was to define the composition of the 'alternative cluster', i.e. the type of contractors that were being considered. From the review of literature on private contractors in Nigeria, two distinctive groups were identified, multinational construction companies (MCC) and local construction companies (LCC). The final contractor selection decision model was developed in the 'network' interface of the ANP software (*Super Decisions)*. The model conformed to the following:

i. *Comparison of nodes in each cluster with one other*
ii. *Comparison of each node with respect to alternatives*
iii. *Comparison of each alternative to all nodes*
iv. *Cluster priority with respect to goal*
v. *Project finance was considered as a focal point in formulating comparison between nodes of different clusters*

4.17.1: Pairwise Questionnaire Survey

Purposeful sampling technique was used to select experts that participated in the survey. The criteria for selection were based on their willingness to participate, qualifications, experience and knowledge of decision-making methodology. The 7 respondents who were selected in pairwise comparison survey constituted decision makers (DM) who participated in the completion of the survey. The questionnaire design implemented the verbal scale recommended by Saaty (1990). The questionnaire template was adapted from Aragones-Beltran et al. (2010) and shown in appendix 3.

4.17.2: Data Simulations: Implementation of Super Decisions Software

After obtaining the feedbacks from the respondents, each of the completed questionnaires was first evaluated for their inconsistency in weight assignment using Super Decisions software (see appendix 3 for manual method). Six out of seven received questionnares had Consistency Ratio CR < 1. Decision Maker DM with CR > 1 reflected inconsistency in some paired comparison matrix and was further contacted for the review of the feedback.

Following the computation of CR for each of the respondents, the feedbacks were aggregated to a single data format using geometric mean (Saaty, 2013). For the analysis of pairwise comparison data, Gencer and Gurpinar (2007) suggested application of computer programmes like Ecnet and *Super Decisions*. Mathematical programs such as Excel and Marple are also considered appropriate. This study implemented *Super Decisions, a* software that provides tools to create and manage ANP model. The suitability of the *Super Decisions* was evident from the ample literature review of referred ANP studies in this study.

4.17.3: Aggregation of Individual Judgements

Prior to data synthesis, the consistent ratio in each of the respondents were computed to validate data. Feedback of the pairwise comparison questionnaire from established decision-making panel (experts selected via purposeful sampling) were first aggregated before data was synthesised using *Super Decisions* software. Lee et al (2013). Saaty (2013) suggested that an effective way to combine the judgements of several individuals to obtain a judgement of a group is the application of a geometric mean. In a similar study carried out by Lee et al (2013), geometric mean was applied to aggregate survey feedback.

To compute the geometric mean for survey data in this study, Microsoft Excel was applied. A spreadsheet for the total responses was first prepared from where geometric mean was computed. To calculate geometric mean following formulae was used:

$$\bar{x}_{\text{geom}} = \sqrt[n]{\prod_{i=1}^{n} x_i} = \sqrt[n]{x_1 \cdot x_2 \cdot \ldots \cdot x_n} \quad \text{.....(iv)}$$

4.18: Hypothesis Testing: ANOVA

In statistics, ANOVA simply means analysis of variance. The technique is used to compare means of three of more samples by using the 'F' distribution. The two main types of tests in ANOVA are 'one-way ANOVA and 'two-way ANOVA'. One-way test is used to test for a difference between two groups. Two-way ANOVA can be applicable in two cases. The first case is when a double test is carried out on a single group. The second is, though two groups are tested, the members of the group are exhibiting more than one function. As it applies in this study, one-way ANOVA test was applied for hypothesis testing. The two groups were independents (predictors) variables and dependent variable. The means of the predictors were computed to reject the null hypothesis or accept the alternative hypothesis.

4.19: Ethical Issues in Research Undertaking

Ethics are vital elements of social research and most especially among academic institutions. Ethics play a vital role in the planning, design and development of a research. The goal of ethics in research is to put adequate measures that prevent anyone from being harmed or suffered adverse consequences from research activities. While success of this study depends on the quality and quantity of information that are extracted from the population, privacy and sovereign of target population are equally important (Denscombe, 2010). Uncontrolled

freedom in data collection violates ethics of social research. This commonly results from involuntary consent of the subjects, exposure of personal identity, and unauthorised access and publication of vital documents by a researcher (Denscombe, 2010).

Prior to the start of this study, ethical issues were considered by Research Committee, detailing nature of required data and methods of data collection. In compliance with the established policies and procedures, a covering letter was attached to survey questionnaire. The letter provides the subject with relevant information about the research in simple and understandable language. In addition, consent letters were completed.

In compliance with research committee ethical standard, key ethical considerations applied in this study were:

1) *Confidentiality of data. Results were used for academic purposes only.*
2) *Clear information to participants on the nature of the research*
3) *Voluntary consent of the participants. Respondents could opt out of the study, if for any reason, they were not comfortable with it.*
4) *Anonymous of participants-Privacy of respondents were maintained throughout the research process.*

4.20: Summary

Research methodology was presented in this Chapter. This was followed with discussion on the methodology of the key decision strategies and value measurement techniques that were applied in the research design and data analysis. The techniques discussed were SSM, ANP, FA, sensitivity analysis, and multiple regression. SSM underpins research design for this study while ANP has been selected and applied to structure questionnaire survey for 'pairwise comparison survey. The results of the survey were synthesised using Super Decisions computer package. The rationale for SSM action research design, the data collection and analysis methods as well as the considerations of research ethics were discussed. This is followed with an in-depth discussion of the conceptual framework in Chapter 5. Chapter 6 presents the analysis of data from web-based questionnaire survey and pairwise comparison survey.

CHAPTER 5 CONCEPTUAL FRAMEWORK AND SID MODEL

5.0: Introduction

The initial findings from construction activities in Nigeria, in Chapter 2 and 3, revealed lack of standardised value framework in procurement practice. The current contractors' selection criteria for public infrastructure delivery are grounded mainly on economic factors, with the principal goal of transferring the risks of project finance to private sector. With the growing preference of PPP, stakeholders' mapping is very critical in the appraisal of project's sustainability. This has necessitated the need for a shift from the traditional to a systemic approach to the evaluation of stakeholders' key attributes for sustainable development during pre-evaluation of contractors for public infrastructure delivery. It also reflected the need for the integration of socio-economic performance indicators to contractors' selection framework.

In this Chapter, a novel sustainable infrastructure delivery (SID) model is developed. The proposed model aims to provide a more systematic and objective approach to contractors' selection process for PPP projects.

5.1: Development of a Conceptual Framework: SID Model

The economic, time and quality approach-decision making strategies are predominantly applied in the selection of contractors by public client to deliver VfM. In many cases lowest initial cost, rather than sustainable infrastructure is achieved. Little consideration is often given to 'real' and 'opportunity' cost during project appraisal phase. SID model is based on an integration of several established decision-making techniques. This rationale is supported by the view of Green (1999) that a single methodology is non-substantial for value study. Other researchers (Diaz-Sarachaga et al., 2017 and Aragones-Beltran et al., 2010) utilised integrated techniques to explore complex decision problems. The model addresses the gap in knowledge

identified by Babatunde and Low (2013) on the need for standardised framework for infrastructure delivery in developed countries.

The SID framework takes the form of a series of three interrelated phases, as highlighted in Figure 5.1.

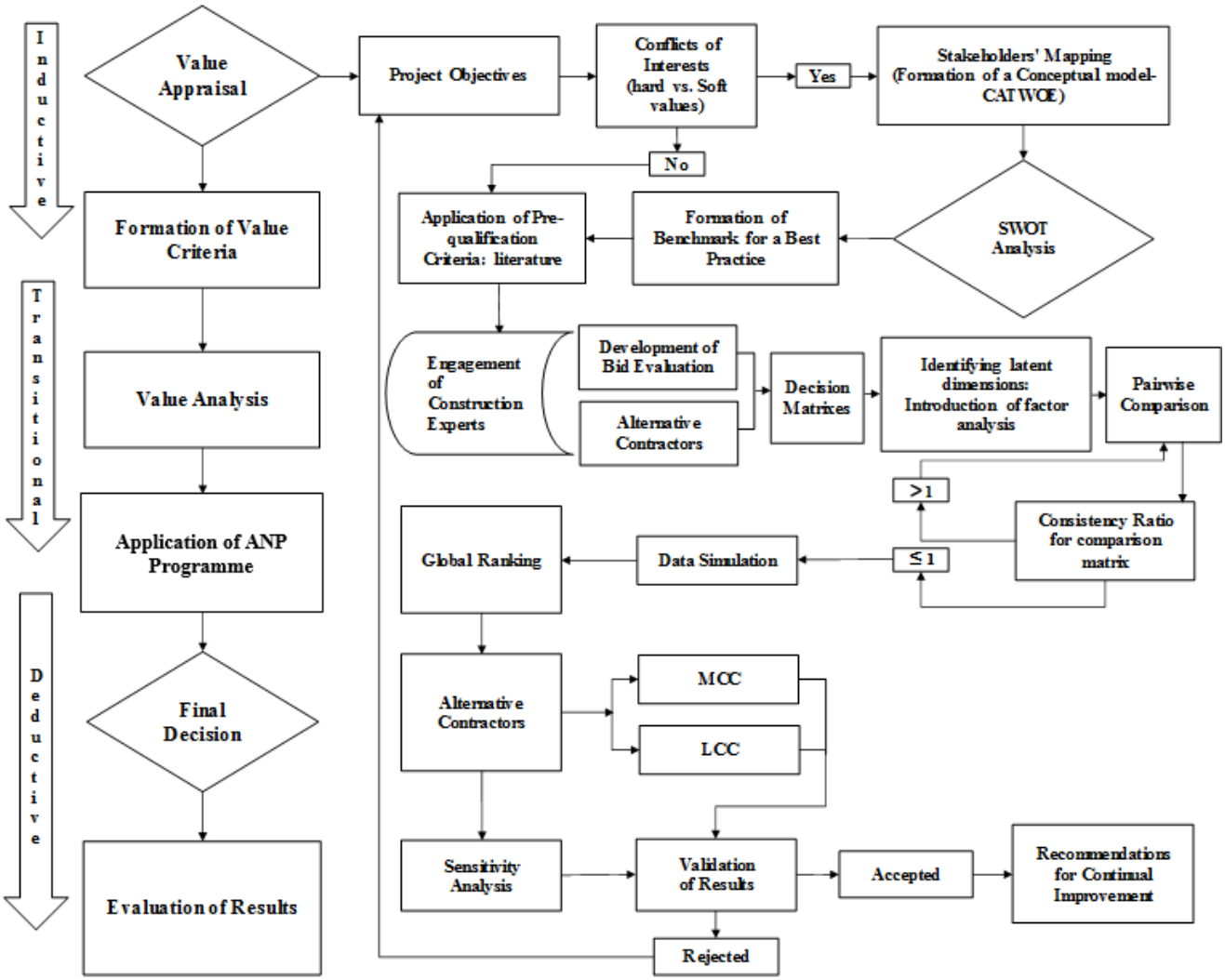

Figure 5-1: A Flowchart for SID conceptual framework

During this research the conceptual framework for SID was presented at distinguished research conferences with a commendable feedback from peer reviews. Constructive criticism was also received, which had helped to refine the model accordingly to become more effective and efficient.

5.2: Inductive Phase

The decision-making process starts with value appraisal. This is arguably the most complex phase. The goal at this phase is to first identify the stakeholders and then investigate and establish the nature of interests and conflicts that exists among them. In most cases, differential views arise on the definition of best value in contractor selection. As such, there are conflicting interests between hard and soft values, and most importantly, how sustainable infrastructure delivery is defined. A stakeholder mapping and SWOT analysis are thus recommended at this phase. Based on extensive literature review and Government publications, current value theory in the Nigerian construction sector is presented in Figure 5.2.

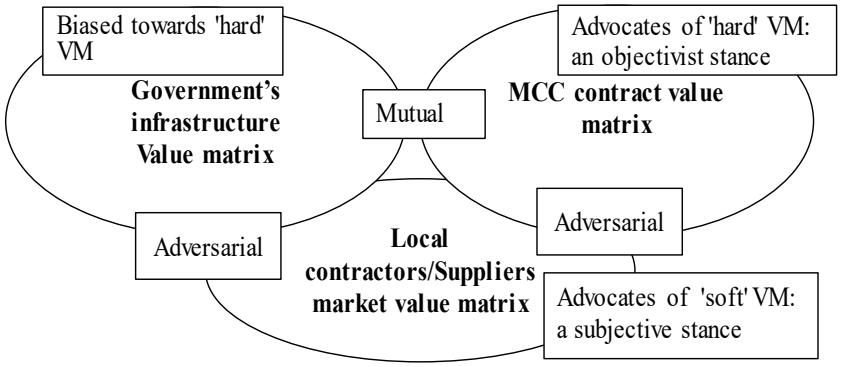

Figure 5-2: Current value theory in the Nigerian construction sector

The common outcome of the mutual/adversarial relationship between MDAs, MCC and local contractors/suppliers often worsen unemployment problem. In addition, the level of social vices is also at the rise.

The current nature of infrastructure delivery in Nigeria is depicted in rich picture diagram presented in Figure 5.3.

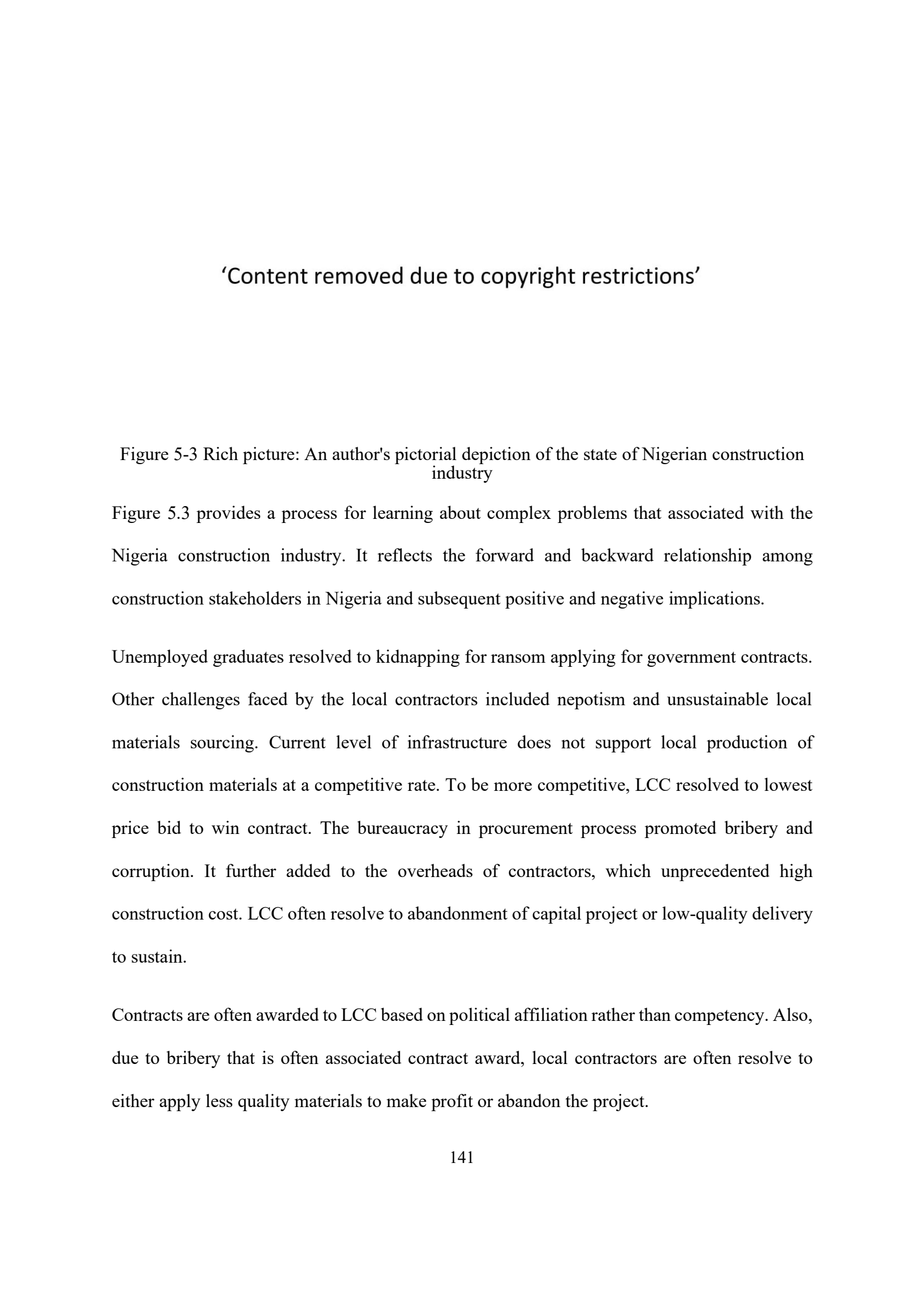

Figure 5-3 Rich picture: An author's pictorial depiction of the state of Nigerian construction industry

Figure 5.3 provides a process for learning about complex problems that associated with the Nigeria construction industry. It reflects the forward and backward relationship among construction stakeholders in Nigeria and subsequent positive and negative implications.

Unemployed graduates resolved to kidnapping for ransom applying for government contracts. Other challenges faced by the local contractors included nepotism and unsustainable local materials sourcing. Current level of infrastructure does not support local production of construction materials at a competitive rate. To be more competitive, LCC resolved to lowest price bid to win contract. The bureaucracy in procurement process promoted bribery and corruption. It further added to the overheads of contractors, which unprecedented high construction cost. LCC often resolve to abandonment of capital project or low-quality delivery to sustain.

Contracts are often awarded to LCC based on political affiliation rather than competency. Also, due to bribery that is often associated contract award, local contractors are often resolve to either apply less quality materials to make profit or abandon the project.

It is evident from the figure that MCC enjoys a cordial relationship and support of the MDAs. Findings revealed that MCC are more likely to support government agencies with project finance. In order to create a conducive environment for the operations of MCC, extra budget is allocated for security. MCC can outsource materials and workers as long they project goal is achieved, with lowest infrastructure being mis conceptual for value for money.

Notwithstanding, uprising of kidnapping of expatriates for ransom, extra security budget, unregulated outsourcing, abandonment of project and rise of unemployment depict unsustainable infrastructure delivery practice in Nigeria.

5.2.1: Conceptualisation of 'CATWOE'

The major aspect of applying systems principles is defining the problem and structuring the decision process. In real life system, it is common that different stakeholders will perceive and approach the same issue differently, as evident from the illustrations in Figure 6.2 and 6.3 respectively. Table 5.1 shows CATWOE analysis as part of SSM methodology employed by this research. It is an analytical method for determining the problems and processes during Soft System Analysis. The mnemonic assists to identify and categorise all the people, processes and external factors involved in the system under scrutiny.

Table 5-1 CATWOE for infrastructure delivery system in Nigeria

	Meaning	Amplified
C	Clients/Customers	They are those who are beneficial or affected by the construction system: • *public, construction companies (MCC and LCC), manufacturers, political parties)*
A	Actors/Agents	It refers to those carry out the activities in the system under scrutiny: • *Engineers, Architects, Quantity Surveyors, Project Mangers, Facility Managers, Ground Workers* (it should be note that the current practice gives absolute right to the main contractor to control and manage material and human resources
T	Transformation	What does changes to the system brings: Sustainable infrastructure delivery framework: • *Integration of social attributes to contractor's pre-evaluation process* • *Labour content* • *Welfare package* • *Skills assessment* • *Health and safety* • *Enforcing agent* • *Continual review of progress and needs for changes*
W	Weltanschauung/ worldview	What are the wider impacts of the transformation? • *Job creation - functional manufacturing sector – innovation and technology – Reduction in social vices – Lower construction cost*
O	Owners	They are the decision makers with power to control the system (legitimate power vs. Illegitimate power). They include: • *MDAs, Private entity, pressured group, militant group*
E	Environmental constraints	They are constraints and limitations that will impact the solution and its success: • *Government fiscal budget* • *Regulations by the World Bank* • *Ethical issues*

5.2.2: Customers (C) /Stakeholders / Clients

'Customers' is used interchangeably with client and stakeholder in the literature to suit a problem or a system that is being investigated. As applied in this study, the first step is to identify those stakeholders and understand how the system affects them.

1) *Public: Benefits from job opportunities being created during infrastructure delivery process and also enjoy better facilities on completion and commission of the infrastructure. However, they may struggle to contribute to the service and maintenance charges of those facilities if they are denied working roles in delivery process.*
2) *Construction companies: The two main categories of contractor being considered are MCC and LCC. Benefits to contractors are economic returns and continuity in business. Both MCC and LCC are affected differently by the current system. LCC are more likely to be forced out of business due to lack of patronage due to their sizes, weak financial strength and lack of innovative prowess. MCC are big in size with all the attributes to compete effectively, but they may suffer hostilities from the host communities, which sometimes result in loss of property and life. The case of kidnap of expatriates for ransom is at the rise and this results in financial lost*
3) *Manufacturers: Just like contractors, benefits they enjoy from the system are productivity and continuity in business. They will force out of the business in case they are not patronised or unable to compete effectively in the market*
4) *Political parties: Infrastructure delivery remains one of the key features used by the political party to prove their worthiness to the public and the reason they should be allowed to continue in office. Good performance of the construction sector upholds their integrity and popularity. In reverse, their reputation is jeopardised if the value that is expected from the public fall below expectation. In budgetary terms, non -functional construction system means the cost of construction will be considerably high due to many uncertainties. It should be note that PPP contract subject to renegotiation. In many cases all the unforeseen lost in profits by the private party is bored by the public entity.*

5.2.3: Actors

Actors are the sum of those who perform key roles in construction process, and they Engineers, Architects, Quantity Surveyors, Project Mangers, Facility Managers, Ground Workers, Manufacturers, and Research organisations. In the system under scrutiny, they are controlled and managed exclusively by the main contractor. The current structure gives absolute freedom to contractors to source for materials and human resources to satisfy economic terms of construction contracts.

5.2.4: Transformation

Transformation is the change that the system brings about i.e. the new approach to infrastructure delivery. In this research, the proposed new approach is sustainable infrastructure delivery framework. The new activities in the transformation process are envisaged to be:

1) *Integration of social attributes to contractor's pre-evaluation process*
2) *Labour content law*
3) *Skills assessment*
4) *Enforcing agent to oversee continual review of progress and needs for changes*

The transformation is the shift from economic based to holistic pre-evaluation criteria for contractor. More specifically, social requirements are made more pronounced. The labour content law will define rules on the sourcing of material and human resources for construction process. Due to the impact of the inputs on the final infrastructure project, there would be a need for an authority who oversees the assessment of the local skills and their capability to perform in the supply chain. There will also be a procedure for a continual review of the system for improvement purposes.

5.2.5: Weltanschauung/Worldview

The wider view of the new change would be a sustainable infrastructure with new attributes that include:

1) *Job creation*
2) *Knowledge sharing*
3) *Reduction in construction cost*

Job creation will create sense of belonging and commitment of the communities. They will enjoy knowledge sharing, which would motivate them to more innovative. The reduction in unemployment level has a direct impact on social vices as large percentage of offenders are school leavers with no job prospects. Furthermore, a prospective decline in crime levels would lead to making construction process safer and saving costs in security budgets.

5.2.6: Owners

Unlike traditional procurement method where the client has the absolute power and ownership, there is a split power and ownership in PPP. Infrastructure Concession Regulatory Commission (ICRC) plays a key role in the management of PPP contracts in Nigeria. They own the legitimate power to enforce the guiding principles. It is important to note that the requirements for procurement are based on the guidelines by Bureau of Public Procurement (BPP). The legislative arm of Government has influence too, as their laws and regulations influence how decisions are made and implemented by the MDAs.

Since PPP is collaboration between public and private entity on risk management, they possess power to stop the functionality of a system if they wish. It implies that, both the public and the private entity must agree on a common ground and make decision to implement the solutions.

The influences of the marginalised stakeholders in the functionality of the system cannot be underestimated. Therefore, there is a need for the community engagement, and recognise their right and the positive impacts they can make to economic reforms agenda.

5.2.7: Environmental Constraints

Despite the benefits of transformation, there are constraints and limitations that may impact SID framework, such as:

1) *Government fiscal budget*
2) *Regulations by the World Bank*
3) *Current infrastructural facilities*
4) *Ethical issues*

Budgets for infrastructure by MDAs are influenced by the allocation from the Government. Limitations in Government's budgetary and planning is a constraint. Lack of funds by the Government makes MDAs less competitive during negotiation process and they are often compelling to the contract terms and conditions of the MCC (Taylor, 2007). It has been noted that Chinese Civil Engineering Construction Company (CCECC) often enjoy a rare privilege in contract arrangement to exclusively source materials and human resources from their preferred locations even when the expertise is available locally (Taylor, 2007).

The current procurement policy in Nigeria was developed based on the pre-request from the World Bank as part of pre-requisite for financial grants. Changes to the current framework would seek for approval of this financial authority.

Over the past decades, progress has been achieved on the delivery of constructed facilities. However, the current delivery is yet not adequate to produce locally at a competitive level and price.

Ethical issues are serious constraints to the transformation. Politics and favouritism remain issues that impact competitive practice and promote corruption. The findings from the literature often reveal that the leading private entities in PPP projects are noted for their preference to source work force from their own country. It is a culture and economic strategy that has been practiced over the past decade to maximise their economic gains in the supply chain.

5.3: Transitional Phase

Transitional phase is the link between inductive and deductive phase. Following explicit illustration of the problematic value appraisal during contractors' pre-evaluation for infrastructure delivery, this phase introduces changes to established practice of decision making in contractor selection. In this phase, key elements that support optimal value in infrastructure delivery are established. They are:

1) *Identification of benchmark for best practice in contractor selection*
2) *Classification of contractors for construction process*

5.3.1: Identification of Benchmark for Best Practice in Contractor Selection

Since International Competitive Bidding (ICB) is applied to virtually all civil and building projects in Nigeria, extensive literature review is conducted to establish best practice in selection criteria for public procurement. Benchmark for best practice in contractor selection is derived based on extensive review of established contractors' selection criteria. The criteria are then subjected to the first-round questionnaire survey, where experts' opinions are sought for ranking of the importance of criteria. By applying FA, the surveyed data results are reduced to manageable variables for the practical application of ANP.

5.3.2: Classification of Contractors for Construction Process

It is very important at this stage to classify contractors that are involved in the selection process for risk management and ethical purposes. In this study, contractors are classified as MCC and LCC, based on ownership.

5.4: Deductive Phase

During contractor selection, conflicts of interests can be inevitable among the stakeholders. Arriving at unbiased conclusion remains a setback in a linear selection approach. Considering the implication of influence among decision criteria on project success, ANP is incorporated to the deductive phase of the model in this research. Construction experts are engaged through questionnaire survey that has adopted ANP methodology. The final data synthesis provided an output of the global rating between the classifications of contractors being considered for selection.

5.5: Summary

This chapter presented the sustainable infrastructure delivery (SID) model developed in this study for the pre-qualification of contractors that are involved in PPP projects in Nigeria. The model is conceptualised on soft system methodology (SSM), benefiting from the integration of analytical network process (ANP) and factor analysis (FA). The model provides a methodological framework for the synergy of tangible and intangible values in contractors' pre-evaluation process. This is necessary due to the weaknesses of the convectional linear approach of assessment. The model is based on three key phases that with a logical transition from a perception to reality during contractors' selection process. The SID model, as discussed in this chapter, represents a systematic and holistic approach to pre-qualification and selection of contractors for PPP projects.

CHAPTER 6 : DATA ANALYSIS

6.0: Introduction

This chapter starts with presentation and analysis of results from the feedback obtained from web-based questionnaire survey. Detailed information on the design and structure of the questionnaire are discussed in the previous Chapter. It proceeds to present the results of hypothesis testing on the views that public infrastructure procurement does not either contribute significantly to job creation or enhance the growth of construction supporting industries. Results of factor analysis, pairwise comparison survey and ANP application are also presented.

6.1: Descriptive Statistics

Descriptive statistics provide a summary of the available data. The basic features of all variables of interest in the dataset are presented in this section. Typically, descriptive statistics include measures of central tendency (mean, median and mode) and measures of variability or spread (range, standard deviation, and variance) (Oladinrin and Ho, 2015; Kaming et al., 1994). The mean or the arithmetic mean simply means the average. It denotes the average of a set of numeric values. The median is the central value of a set of values, ranked in ascending or descending order. The mode is the value which occurs most frequently in a set of scores or scale.

The summary statistics for the scale variables, simple graphics and partial correlation coefficients are presented in this section. Variance and standard deviation are measures of dispersion which show the amount of variation or spread in the scores, or values of, a variable. Variance measure the amount of variability in a set of scores while standard deviation measures the amount of spread or dispersion in a set of scores.

6.2: Analysis of the Demographic Data

The introductory section of the questionnaire sought for the background information about the respondents. Specifically, data collected focused on respondents' discipline, nature of industry, education level, current position, years of experience, and awareness of private funding for the procurement of public projects in Nigeria. Data obtained is presented in this section.

6.2.1: Field of Work

A feedback of 143 questionnaires was obtained comprising of civil engineers, quantity surveyors, architects and construction managers.

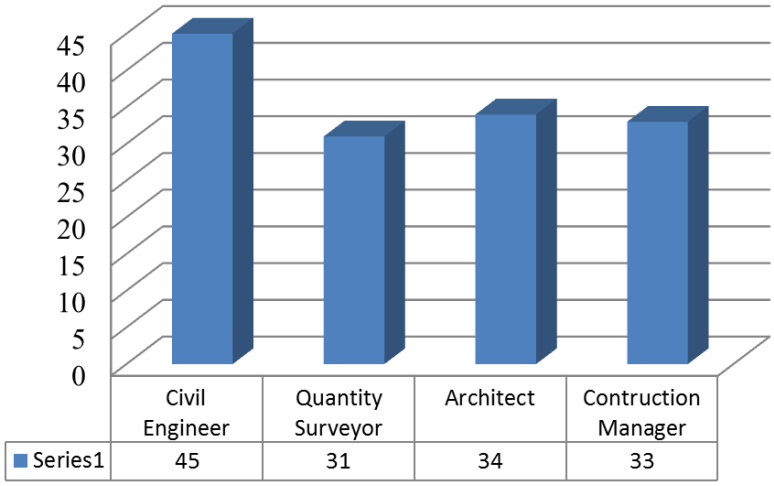

Figure 6-1: Responses based on discipline

From Figure 6.1, The response rate for civil engineers, quantity surveyors, architects and construction managers were 45 (31.5%), 31 (21.7%), 34 (23.8%), and 33 (23.1%) respectively. It could be deduced that four categories of experts that were interviewed were fairly represented.

6.2.2: Level of Education

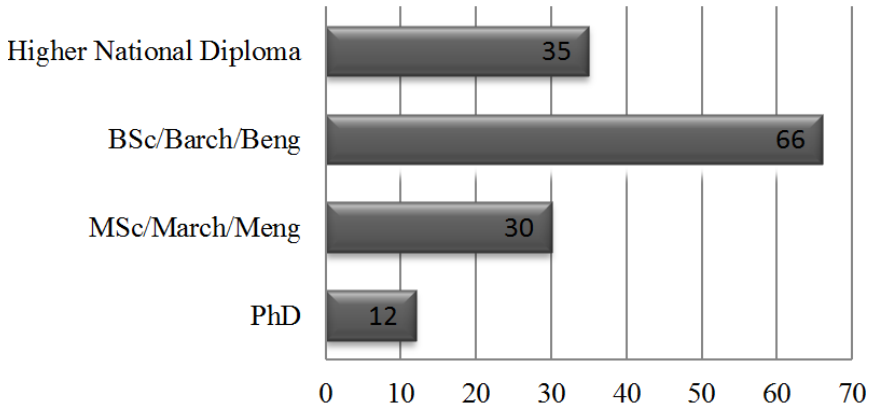

Figure 6-2: Responses based on level of education

From figure 6.2, the level of education of the respondent is quite encouraging. The minimum level of education is HND, which represent 24.5% of feedback. 8.4% of the respondents had obtained PhD, while 21% hold MSc. 46.1% of the respondent had completed degree programme at the University. This indicates that respondents are educationally empowered to respond appropriately to the questions asked.

6.2.3: Nature of Industry

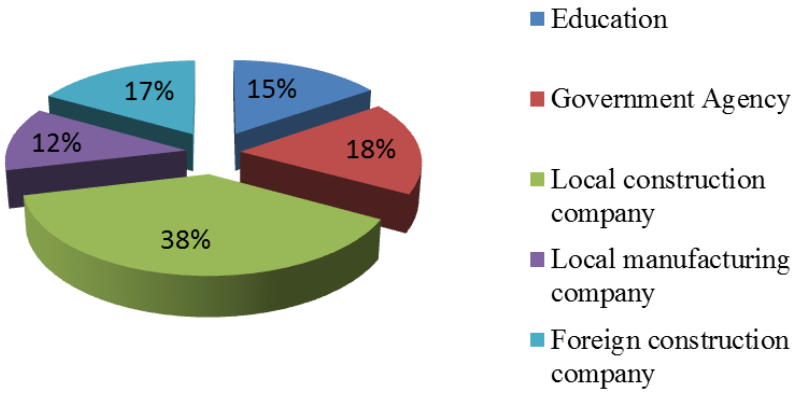

Figure 6-3: Responses based on nature of industry

From Figure 6.3, greater portion of the respondents 38% are from local construction companies. This could be explained by the fact that, though local contractors are relatively small, they are large in number. In addition, the attached cover letter asked for the assistance of respondents in sharing the survey links with their colleagues.

6.2.4: Current Position

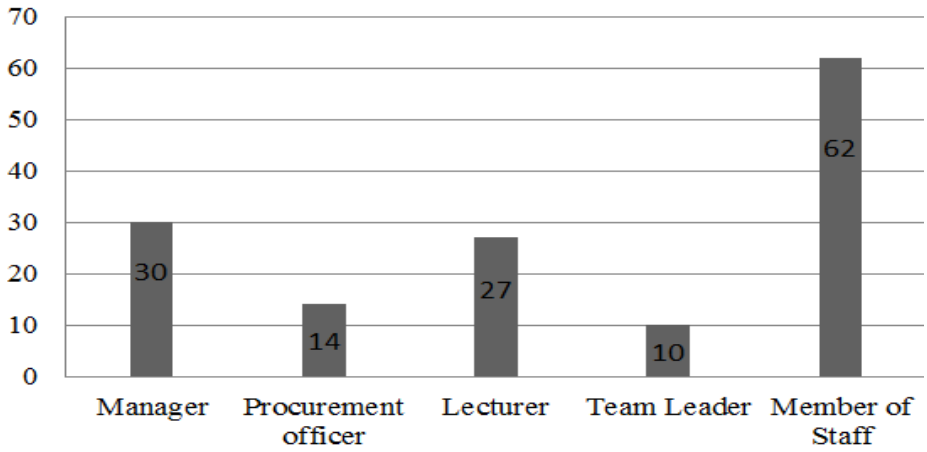

Figure 6-4: Responses based on current position

From Figure 6.4, 30 of the respondents are managers, 14 are procurement officers, 27 are academics, and 10 are team leaders, whilst 62 are members of staff. The member of staff represents 43.1% of the sample. This percentage could be considered quite high to validate responses obtained. However, Figure 6.3 shows that largest percentage of sample size based on nature of industry is local construction company. By nature, they are small in sizes and the members of staff are often multi-tasking, engaging in virtually all form of activities in the business. The background study on the level of education (see Figure 6.2) revealed that the lowest education qualification among respondents is 'higher national diploma. This ascertains the relatively high qualifications levels of respondents regardless of their official ranking and title. Overall, the figure shows that respondents are active in the industry.

6.2.5: PPP Awareness

To establish the validity of the feedback, awareness of respondents on the public private initiatives policy for infrastructure procurement were confirmed. As shown in Figure 6.5 below, 77 of the respondents acknowledged they were very aware of government economic reforms on infrastructure procurement through private finance initiatives (representing 54% of the sample size). 62 of the respondents (43%) were aware. Only 4 respondents can be considered to have a limited average of PPP in the Nigeria public infrastructure, and they represent just 3% of the sample size.

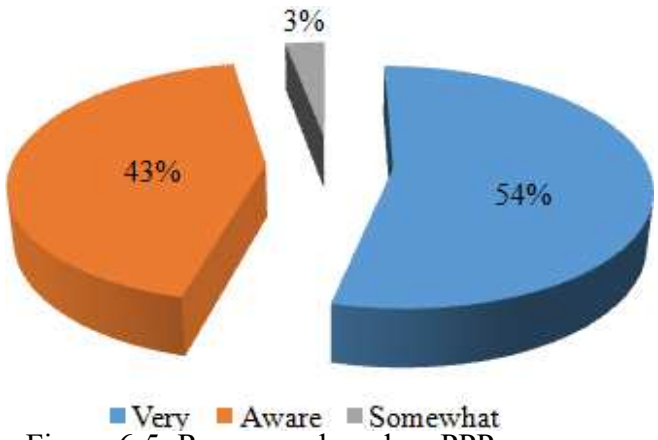

Figure 6-5: Responses based on PPP awareness

6.3: Multicollinearity and Singularity

Multicollinearity exits when there is strong linear relationship among the predictor variables. It is one of the major challenges in survey data analysis, as evident in this study. It implies that variables are interlinked and/or replicated, thereby making regression coefficients unstable and unreliable for prediction (Katrutsa and Strijov, 2017). In this dataset consisted of 55 selection criteria as established from literature review, there were variables with significant correlations. Furthermore, the determinate of the correlation matrix was 4.86E-006 (which is less than 0.00001) also strengthens the evidence of multicollinearity in the data. This was resolved by the process of elimination of variables for which values were greater than 0.05 and correlation

greater than 0.9. The iteration process continued until non-significant linearly related variables were achieved in the model. Finally, 16 variables were remaining, with a determinate value of 0.054, which is greater than the required value of 0.00001.

6.4: Ranking of Criteria

After multicollinearity in the data set was resolved, descriptive statistics was used to verify the ranking of the 16 criteria before further data analysis was undertaken.

Table 6-1 Ranking of selection criteria

Variable	Mean	Std. Dev.	Rank
Working and operating capitals	4.76	.559	1
Experience in project of similar nature	4.56	.498	2
Availability of equipment	4.49	.529	3
Quality and quantity of human resources	4.40	.533	4
Project management experience	4.40	.752	5
Adequate training for operating process	4.39	.504	6
Claims and disputes history	4.38	.768	7
Employee well-being	4.31	.481	8
Proposed construction methods	4.19	1.000	9
Site safety records	4.08	1.008	10
Employment creation for locals	3.99	.731	11
Environmental management certification	3.94	1.152	12
Contractor social responsibility initiatives	3.43	.792	13
Cooperation with workers' union	3.39	.880	14
Relationship with insurance companies	3.17	1.171	15
Local material sourcing	2.07	.909	16

The key surprise from Table 6.1 is the 'local material sourcing' being the least in the ranking. While local sourcing of materials is critical to SID, the ranking results validate lack of enabling environment for competitive local production. Key barriers include inefficient power supply ineffective transport system. Cost of energy and local transportation of materials and finished products make importation of construction material to be better cost effective.

From table 6.1, it could further be observed that in majority the mean values of the criteria do not show a significant variance. This information obtained from Table 6.1 may provide useful viewpoint during data discussion when the descriptive statistics ranking of criteria are compared to the new values, after the implementation of the ANP.

6.5: Factor Extraction

Prior to the extraction of factors, various tests were used to assess the suitability of the respondent data for factor analysis. The Kaiser-Meyer-Oikin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity tests were carried out to test that the survey data was adequate for factor analysis. The KMO index ranges from 0 to 1, with KMO no less than 0.50 (Oladinrin and Ho, 2015; Oyedele, 2013; Williams et al., 2010; Yang et al., 2009). The Barlett's Test tests if 'k' samples are from populations with equal variances. The Bartlett's Test of Sphericity tests should be significant ($p < .05$) for factor analysis to be suitable (Williams et al., 2010).

Table 6-2 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.519
Bartlett's Test of Sphericity	Approx. Chi-Square	397.571
	df	120
	Sig.	.000

From Table 6.2, the value of KMO for this study is 0.519, which is greater than the minimum value of 0.5, and therefore, satisfies the condition for factor analysis. Secondly, the value of the Barlett's Test of Spherity is 397.571, with the associated significant level: p = 0.000, which suggest that the population correlation matrix is not an identity matrix (Oladinrin and Ho, 2015). Values less than 0.05 of the significance level indicate that a factor analysis could be useful with data.

6.6: The Scree Test

The Scree Test is the technique used for determining the number of factors to retain. The Scree Test involves plotting the eigenvalue of each component in the initial solution. Ideally, the idea is to extract the component on a steep slope. The components in the shallow slope will contribute less significantly to the solution. Usually, the scree plot is negatively decreasing. The eigenvalue is highest for the first factor and moderate but decreasing for the next few factors before reaching small values for the last factor and becoming very shallow thereafter.

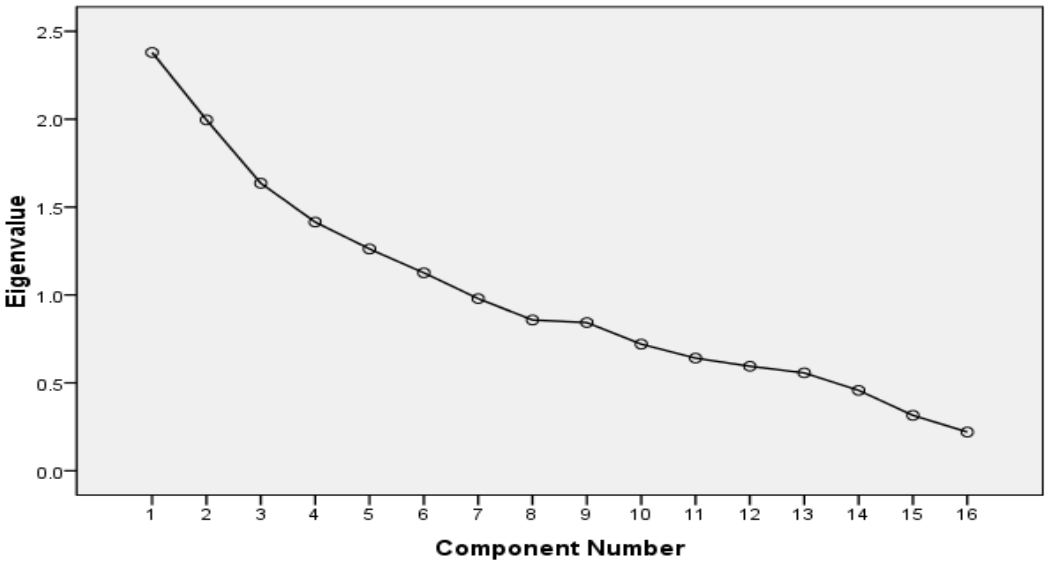

Figure 6-6: Scree Plot

In the graph shown in Figure 6.6, the line begins to tail off after five factors before a stable decrease is reached. After the sixteenth component, the slope became shallow. The graph further validates the appropriateness of 16 factors that were retained.

6.7: Total Variance Explained

The variance explained by the initial solution, extracted components, and rotated components are displayed in Table 6.3.

Table 6-3 Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.380	14.875	14.875	2.380	14.875	14.875	1.885	11.782	11.782
2	1.996	12.478	27.353	1.996	12.478	27.353	1.866	11.660	23.442
3	1.636	10.223	37.577	1.636	10.223	37.577	1.708	10.672	34.115
4	1.415	8.845	46.421	1.415	8.845	46.421	1.538	9.612	43.727
5	1.262	7.887	61.346	1.126	7.038	61.346	1.336	8.350	61.346
6	1.126	7.038	61.308						
7	.979	6.122	67.468						
8	.858	5.360	72.828						
9	.843	5.269	78.098						
10	.720	4.502	82.600						
11	.641	4.005	86.604						
12	.594	3.715	90.319						
13	.557	3.480	93.799						
14	.457	2.857	96.656						
15	.315	1.969	98.625						
16	.220	1.375	100.000						

Extraction Method: Principal Component Analysis

6.7.1: Total Variance Explained, Initial Solution

The principal components analysis was used to identify the underlying factors. The first section of the table shows initial eigenvalues. The total is the eigenvalue i.e. the amount of variance in the original variables accounted for by each component. The % of variance is the ratio, expressed in percentage, of the variance accounted for by each component to the total variance in all the variables. For example, factor 1 explains 14.875% of total variance. The cumulative

% column gives the percentage of variance accounted for by the *n* components. For instance, the cumulative % of the third component is 37.577 (the sum of the percentage of variance for the first, second, and third components).

6.7.2: Total Variance Explained, Extracted Components

For the initial solution, the number of components is same as the number of variables. The sum of eigenvalues is equal to the number of components. For this analysis it is pre-set that only the eigenvalues greater than 1 will be extracted. This reflected that 5 principal components form the extracted solution, as shown under the extracted components section. They explain nearly 61% of the variability in the original 16 variables. This implies that the complexity of the data set can be reduced by using these components, with a 39% potential loss of information.

6.7.3: Total Variance Explained, Rotated Components

The orthogonal rotation using the varimax method was performed. The results are shown in Table 6.4.

Table 6-4 Component Matrix

	Components				
	1	2	3	4	5
Adequate training			.761		
Cooperation with workers' union	.717				
Quality of human resources		.896			
Availability of equipment		.878			
Employment creation for locals	.695				
Environmental management cert.					.664
Working capitals		.650			
Proposed construction methods			.849		
Local material sourcing					.500
Relationship with insurance companies				-.668	
Contractor social responsibility initiatives	.648				
Employee well-being	-.489				
Site safety records				.486	
Experience in project of similar nature			-.792		
Project management experience			.475		
Claims and disputes history				.430	

Extraction Method: Principal Component Analysis
Rotation Method: Varimax and Kaiser Normalization
a. 5 components extracted.

As shown in Table 6.4, the 16 factors were reduced to five components after underlying dimensions between measured variables had been stablished.

Inference from Table 6.4 (Component Matrix) means that, though 55 variables were initially included in the web-based questionnaire survey; there is a high degree of multicollinearity among the data set. 16 variables are the most critical criteria, and they can be used effectively to predict priorities among prospective contractors.

After identifying the critical contractors' pre-evaluation criteria, it was important for this study to identify the underlying dimension behind these criteria, in order to satisfy part of the research objectives. This will facilitate the replacement of the entire data set with a smaller number of uncorrelated principal factors for the implementation of the ANP.

Each component was interpreted and labelled based on the criteria that made up the group as follows:

1) *Component 1 denotes social integration*
2) *Component 2 denotes asset*
3) *Component 3 denotes managerial skill and innovation*
4) *Component 4 denotes reputation and integrity*
5) *Component 5 denotes environmental conversation*

6.8: Data Simulations: Implementation of ANP

Together with 'an alternative cluster', the five established components were developed to ANP based contractor selection model. Figure 6.7 is the graphical representation of the ANP data stimulation, using *Super Decisions* software.

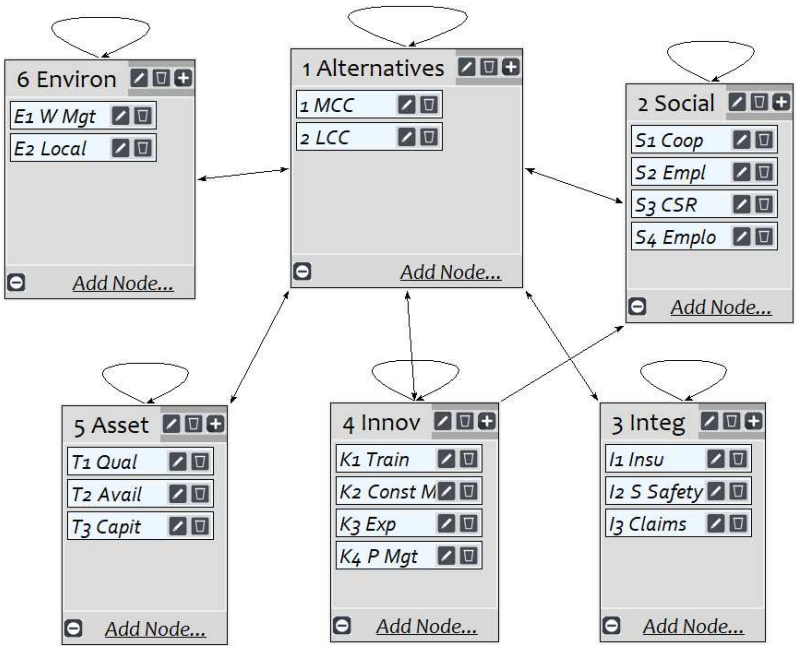

Figure 6-7: ANP based contractor selection model in Super Decisions

where E1 = Environmental management cert., E2 = Local material sourcing, L1= Relationship with insurance companies, L2= Site safety records, L3= Claims and disputes history, K1= Adequate training for operating process, K2= Proposed construction methods, K3= Experience in project of similar nature, K4= Project management experience, S1= Cooperation with workers' union, S2= Employment creation for locals, S3= Contractor social responsibility initiatives, S4= Employee well-being, T1= Quality of human resources, T2= Availability of equipment, T3= Working capital

It should be noted that a cluster connection cannot be directly created. A cluster connection appears when a node (s) in one cluster is connected to a node (s) in another cluster. A loop on a cluster indicates that at least 2 nodes are linked within the cluster (inner dependence). An arrow indicates that relation exist between nodes of at least two clusters. The source of the arrow is the cluster that contains a ‘parent node’. The ‘sink cluster’ contains ‘children’s nodes’. The established relationship between and within elements of the clusters were developed to pairwise questionnaire.

6.8.1: Computing Unweighted Supermatrix

Unweighted supermatrix represents the results of the paired comparison of nodes of the network with relationship between them. Relative importance weights (eigenvectors) obtained are showing in the appropriate column of the supermatrix. The purpose of the table is to show the importance of the nodes in each of the clusters, independently of the influences outside the cluster.

Table 6-5: Computed Unweighted Matrix

Main Network: Final Solution.sdmod: ratings: Unweighted Super Matrix

Clusters	Nodes	1 MCC	2 LCC	S1 Coop	S2 Empl	S3 CSR	S4 Emplo	I1 Insu	I2 S Safety	I3 Claims	K1 Train	K2 Const M	K3 Exp	K4 P Mgt	T1 Qual	T2 Avail	T3 Capit	E1 W Mgt	E2 Local
1 Alternatives	1 MCC	0.000000	1.000000	0.696970	0.212766	0.885057	0.777778	0.777778	0.736842	0.416667	0.848485	0.722222	0.859155	0.600000	0.565217	0.805447	0.859155	0.756098	0.161291
	2 LCC	1.000000	0.000000	0.303030	0.787234	0.114943	0.222222	0.222222	0.263158	0.583333	0.151515	0.277778	0.140845	0.400000	0.434783	0.194553	0.140845	0.243902	0.838709
2 Social	S1 Coop	0.116264	0.108647	0.000000	0.261800	0.285670	0.231702	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S2 Empl	0.325745	0.645961	0.356921	0.000000	0.341064	0.575014	0.000000	0.000000	0.000000	0.833333	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S3 CSR	0.056397	0.074999	0.066255	0.115588	0.000000	0.193284	0.000000	0.000000	0.000000	0.166667	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S4 Emplo	0.501594	0.170393	0.576824	0.622611	0.373266	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3 Integ	I1 Insu	0.249563	0.207904	0.000000	0.000000	0.000000	0.000000	0.000000	0.756098	0.500000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	I2 S Safety	0.661518	0.065599	0.000000	0.000000	0.000000	0.000000	0.761905	0.000000	0.500000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	I3 Claims	0.088919	0.726498	0.000000	0.000000	0.000000	0.000000	0.238095	0.243902	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4 Innov	K1 Train	0.117036	0.070514	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.241515	0.324521	0.253963	0.000000	0.000000	0.000000	0.000000	0.000000
	K2 Const M	0.355883	0.158337	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.360429	0.000000	0.532177	0.307117	0.000000	0.000000	0.000000	0.000000	0.000000
	K3 Exp	0.456405	0.126432	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.389293	0.559432	0.000000	0.438920	0.000000	0.000000	0.000000	0.000000	0.000000
	K4 P Mgt	0.070676	0.644716	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.250279	0.199053	0.143302	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5 Asset	T1 Qual	0.099910	0.177630	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.322580	0.500000	0.000000	0.000000
	T2 Avail	0.238565	0.127062	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.163934	0.000000	0.500000	0.000000	0.000000
	T3 Capit	0.661524	0.695308	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.836066	0.677420	0.000000	0.000000	0.000000
6 Environ	E1 W Mgt	0.583333	0.322580	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	1.000000
	E2 Local	0.416667	0.677420	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000

6.8.2: Computing Weighted Supermatrix

At this stage of the computation, the relative importance between elements of different clusters is considered as long there are relationship between them is established in the network. This is critical stage where the decision process where the decision process is transformed from linear to systemic approach. To achieve weighted supermatrix, i.e., column stochastic, clusters priorities were computed. Influences of the clusters were computed. Elements in each cluster were then multiplied by the cluster priority.

Table 6-6: Computed Weighted Matrix

Main Network: Final Solution.sdmod: ratings: Weighted Super Matrix

Clusters	Nodes	1 MCC	2 LCC	S1 Coop	S2 Empl	S3 CSR	S4 Emplo	I1 Insu	I2 S Safety	I3 Claims	K1 Train	K2 Const M	K3 Exp	K4 P Mgt	T1 Qual	T2 Avail	T3 Capit	E1 W Mgt	E2 Local
1 Alternatives	1 MCC	0.000000	0.082549	0.199134	0.060790	0.252874	0.222222	0.388889	0.368421	0.208333	0.118032	0.288271	0.342927	0.239487	0.125604	0.178988	0.190923	0.216028	0.046083
	2 LCC	0.082549	0.000000	0.086580	0.224924	0.032841	0.063492	0.111111	0.131579	0.291667	0.021077	0.110874	0.056218	0.159658	0.096618	0.043234	0.031299	0.069686	0.239631
2 Social	S1 Coop	0.017972	0.016794	0.000000	0.187000	0.204050	0.165502	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S2 Empl	0.050353	0.099851	0.254943	0.000000	0.243617	0.410725	0.000000	0.000000	0.000000	0.542903	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S3 CSR	0.008718	0.011593	0.047325	0.082563	0.000000	0.138060	0.000000	0.000000	0.000000	0.108581	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S4 Emplo	0.077535	0.026339	0.412017	0.444722	0.266618	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3 Integ	I1 Insu	0.044045	0.036692	0.000000	0.000000	0.000000	0.000000	0.000000	0.378049	0.250000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	I2 S Safety	0.116749	0.011577	0.000000	0.000000	0.000000	0.000000	0.380952	0.000000	0.250000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	I3 Claims	0.015693	0.128217	0.000000	0.000000	0.000000	0.000000	0.119048	0.121951	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4 Innov	K1 Train	0.022339	0.013459	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.145116	0.194990	0.152595	0.000000	0.000000	0.000000	0.000000	0.000000
	K2 Const M	0.067929	0.030222	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.075477	0.000000	0.319761	0.184533	0.000000	0.000000	0.000000	0.000000	0.000000
	K3 Exp	0.087115	0.024133	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.081521	0.336138	0.000000	0.263728	0.000000	0.000000	0.000000	0.000000	0.000000
	K4 P Mgt	0.013490	0.123059	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.052410	0.119602	0.086104	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5 Asset	T1 Qual	0.027907	0.049616	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.250896	0.388889	0.000000	0.000000
	T2 Avail	0.066637	0.035491	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.127504	0.000000	0.388889	0.000000	0.000000
	T3 Capit	0.184778	0.194214	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.650274	0.526882	0.000000	0.000000	0.000000
6 Environ	E1 W Mgt	0.067779	0.037482	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.714286
	E2 Local	0.048414	0.078711	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.714286	0.000000

6.8.3: Computing Limit Matrix

The supermatrix is at a stable state when row values converge to the same value for each column of the matrix. To achieve this, the weighted supermatrix was raised to powers by multiply by itself. The limit matrix was reached when the column of numbers was the same for every column and the matrix multiplication could be halted. The limit matrix in table 6.7 shows the local relative weights for all the variables in the supermatrix.

Table 6-7: Computed Limit Matrix

Main Network: Final Solution.sdmod: ratings: Limit Matrix

Clusters	Nodes	1 MCC	2 LCC	S1 Coop	S2 Empl	S3 CSR	S4 Emplo	I1 Insu	I2 S Safety	I3 Claims	K1 Train	K2 Const M	K3 Exp	K4 P Mgt	T1 Qual	T2 Avail	T3 Capit	E1 W Mgt	E2 Local
1 Alternatives	1 MCC	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303	0.154303
	2 LCC	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687	0.087687
2 Social	S1 Coop	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856	0.029856
	S2 Empl	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123	0.063123
	S3 CSR	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190	0.019190
	S4 Emplo	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763	0.059763
3 Integ	I1 Insu	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712	0.028712
	I2 S Safety	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315	0.035315
	I3 Claims	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389	0.021389
4 Innov	K1 Train	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986	0.017986
	K2 Const M	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341	0.028341
	K3 Exp	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811	0.031811
	K4 P Mgt	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944	0.019944
5 Asset	T1 Qual	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542	0.083542
	T2 Avail	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089	0.079089
	T3 Capit	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538	0.141538
6 Environ	E1 W Mgt	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023	0.049023
	E2 Local	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389	0.049389

Data in Figure 6.8 contains ‘limiting’ and ‘normalised by cluster’ columns. ‘Limiting’ column are data obtained directly from limit matrix (see figure 6.7).

Here are the priorities.

Icon	Name	Normalized by Cluster	Limiting
No Icon	1 MCC	0.63764	0.154303
No Icon	2 LCC	0.36236	0.087687
No Icon	S1 Coop	0.17365	0.029856
No Icon	S2 Empl	0.36714	0.063123
No Icon	S3 CSR	0.11161	0.019190
No Icon	S4 Welf	0.34760	0.059763
No Icon	I1 Insu	0.33614	0.028712
No Icon	I2 S Safety	0.41345	0.035315
No Icon	I3 Claims	0.25041	0.021389
No Icon	K1 Train	0.18338	0.017986
No Icon	K2 Const M	0.28895	0.028341
No Icon	K3 Exp	0.32433	0.031811
No Icon	K4 P Mgt	0.20334	0.019944
No Icon	T1 Qual	0.27466	0.083542
No Icon	T2 Avail	0.26002	0.079089
No Icon	T3 Capit	0.46533	0.141538
No Icon	E1 W Mgt	0.49814	0.049023
No Icon	E2 Local	0.50186	0.049389

Figure 6-8: Nodes priorities

Figure 6.8 are nodes priorities. ‘Normalised by cluster’ column are the normalised values of the limit matrix, and it can be interpreted as follow:

The value of nodes represents their values after sum of nodes in each cluster have been normalised i.e. sum to 1 (100%). For instance, in ‘social skills cluster, four nodes (S1, S2, S3 and S4), have values of S1 = 0.17365, S2 = 0.36714, S3 = 0.11161, S4 = 0.34760. This mean that the percentage of the priorities of the four nodes in ‘social skills cluster, S1 = 17%, S2 = 37%, S3 = 11%, and S4 = 35% respectively, totalling 100%.

The results for the priorities of the alternatives, the number shown in the 'raw column' (Figure 6.9) are directly from the limit supermatrix.

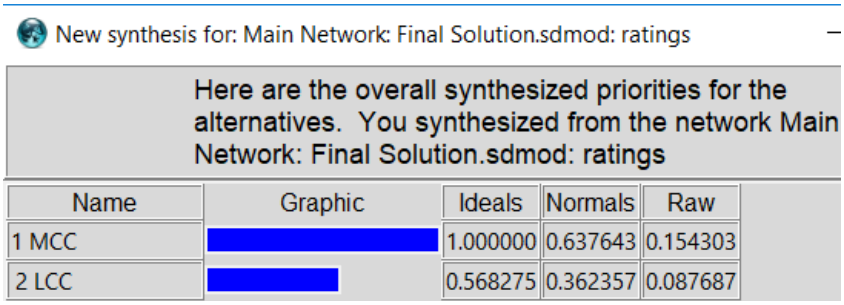

Figure 6-9: Final solution

The values were normalised to obtain the priorities in the 'normal column', which added up to 1. The priorities in the 'ideal column' were obtained by dividing each raw number by the largest, 0.637643, which resulted in the 'ideal' alternative having a value of 1.

6.9 Hypothesis Testing and ANOVA

The two hypotheses tested were:

- *H1: Public infrastructure procurement does not contribute significantly to job creation*
- *H2: Public infrastructure procurement does not enhance the growth of construction supporting industries*

They are based on the responses obtained from the experts on the ranking of construction benefits.

According to PricewaterhouseCoopers, cited in Babatunde and Low (2013), benefits that are associated with construction are in 5 phases, namely,

i. *'direct impacts' (milestone in infrastructure delivery)*
ii. *'multiplier effects' (significant improvement in construction job creation)*
iii. *'wider economic benefits' (improvement in the growth of supporting industries)*
iv. *'higher quality construction' (strive towards competing globally)*

Table 6-8 Ranking of construction benefits variables

	N	Mean	Std. Deviation	Variance
Milestone in infrastructure delivery	143	3.74	.709	.503
Significant improvement in construction job creation	143	4.09	.701	.492
Improvement in the growth of supporting industries	141	3.88	.732	.535
Strive towards competing globally	143	3.83	.760	.577

Table 6.8 presents the descriptive statistics on the ranking of construction benefit variables as applicable to the Nigerian context. Considering the mean value of the variables, 'Significant improvement in construction job creation' is the highest with 4.09). It is followed in second position by 'Improvement in the growth of supporting industries' with 3.88. Both were developed to hypothesis to validate job creation and growth of construction supporting industries.

6.9.1: Hypothesis 1: Job Creation

- *H_0: Public infrastructure procurement does not contribute significantly to job creation (null hypothesis)*
- *H_a: Public infrastructure procurement contribute significantly to job creation (alternative hypothesis)*

Table 6-9 ANOVA Model Summary[a]

Model		Sum of Squares	df	Mean Square	F	Sig.	R	R Square
1	Regression	12.283	16	.768	1.681	.058[b]	.419	.176
	Residual	57.535	126	.457				
	Total	69.818	142					

Table 6.9 provides the overall significance of public infrastructure procurement to job creation. Regression analysis was performed to test the relationship between the 16 independent variables and each of the dependent variables: 1) job creation, and 2) growth of construction supporting industries. For multiple regression models, R is the correlation between the observed and predicted values of the dependent variable. R^2 is the square of this correlation and it ranges from 0 to 1. If there is no linear relation between the dependent and the independents variable, R^2 is 0 or very small. If all the observations fall on the regression line, then R^2 is 1.

The F statistic is used to test the hypothesis that d slope is equal to 0. The linear relation is highly significant if the p value for the F is less than 0.0005.

The p-value column provides the individual significance of each independent variable in the regression equation and tells whether the variable is making statistically significant contribution. A variable must have a significant value of alpha less than 0.05 to make a significantly unique contribution.

There is a moderate positive correlation between public infrastructure procurement and job creation (R=0.419). Despite this relationship, the R-squared shows that the data only explained 17.6% of job creation; this implies that the contributions of public infrastructure procurement are minimal to job creation. In conclusion, at 5% level of significance, there is enough evidence to conclude that the public infrastructure procurement does not contribute significantly to job creation (p-value=0.058).

Based of decision rule that null hypothesis is rejected if P – value is less 0.05, alternative hypothesis (H_a) (Public infrastructure procurement contribute significantly to job creation) is thereby accepted.

6.9.2: Hypothesis 2: Growth of Construction Supporting Industries

- *H_0: Public infrastructure procurement does not enhance the growth of construction supporting industries*
- *H_a: Public infrastructure procurement enhance the growth of construction supporting industries*

Table 6-10 ANOVA Model Summary[b]

Model		Sum of Squares	df	Mean Square	F	Sig.	R	R Square
1	Regression	5.053	16	.316	.560	.908[b]	.260	.067
	Residual	69.897	124	.564				
	Total	74.950	140					

Table 6.10 provides the overall significance of public infrastructure procurement enhancing the growth of construction supporting industries. Contrary to job creation, public infrastructure procurement has an extremely low correlation (R=0.260) with the growth of construction supporting industries. Conclusively, the p-value (0.908) is significantly greater than 0.05.

Hence, we fail to reject the null hypotheses and conclude that public infrastructure procurement does not enhance the growth of construction supporting industries. Additionally, the R-squared indicate that only 6.7% variations in the growth of construction supporting industries can be explained by public infrastructure procurement. This is very low, implying little or no enhancement, which further strengthen the failure to reject the null hypothesis.

6.10: Summary

In this Chapter, data analysis of the questionnaire survey was presented. The target population consisted of architects, quantity surveyors, engineers and construction managers were fairly distributed. Descriptive statistics were used for the analysis of the background information of the respondents to deduce facts on respondents' field of work, level of education, current position in place of work, nature of industry they were working, and degree of knowledge on PPP. Respondents showed good knowledge of PPP and they had satisfactory qualifications and actively engaged in construction activities.

Considering the nature of the study and the purpose of data collection, exploratory factor analysis was implemented to gauge critical selection criteria from the 55 variables of web-based questionnaire data set. The data set was reduced to 16 after multicollinearity had been solved. They were developed to pairwise comparison survey, compliant with the ANP methodology. The overall priorities of data synthesis predicted MCC as the most sustainable contractors to deliver sustainable infrastructure. Meanwhile hypothesis testing failed to reject the theories that public infrastructure procurement does not neither contribute significantly to job creation, nor enhance the growth of construction supporting industries. This requires a further discussion, considering the importance of job creation and growth of local industries in the government economic reforms agenda.

CHAPTER 7 : DISCUSSION OF RESEARCH FINDINGS

7.0: Introduction

As discussed in Chapter 1, the aim of this research is to develop framework criteria for contractor selection that Nigerian government can use to achieve value in the delivery of sustainable infrastructure project. SSM was adapted for research methodology. The research methods applied in the study included literature review, web-based questionnaire survey and pairwise comparison survey. This chapter discusses the research findings from the literature reviews and data analysis results that were presented in the preceding chapter.

7.1: Applied Data Analysis Techniques

Data analysis techniques used in this study serve the purpose of:

1) *Data presentation*
2) *Data suitability*
3) *Data reduction*
4) *Data aggregation*
5) *Data synthesis*

Statistical tools applied were IBM Statistical Package for Social Science (SPSS) Statistics 22 and Super Decisions (computer package that implement ANP). Both are explained in detail in Chapter 4.

7.2: Descriptive Statistics

Descriptive statistics were used to interpret questionnaire feedback and for the interpretation of analysed data. Descriptive statistics medium applied include bar chart, pie chart, tables and graph. Bar and pie charts provided the summary of the sample features (background information of respondents that included discipline, industry of work education level, position and awareness on PPP contract as a key strategy for the procurement of constructed facilities in Nigeria) and the measures.

7.3: Research Findings

These are related to both analysis of secondary and primary data obtained during the course the research. In general, the findings of this study are consistent with the key discussions in the literature regarding a need for contractors' selection criteria for sustainable infrastructure delivery in Nigeria. The findings from the primary data analysis further affirmed the hypothetical stance on the non-conformity of the current framework for pre-evaluation of contractors for PPP infrastructure projects towards employment creation and local empowerment. In general, there is a slender evidence to support the fact that MCC adequately promote knowledge transfer and empowerment ideology in infrastructure supply chain in Nigeria. The usage of CSR, by multinational organisation, as a strategy for social sustainable is viewed as non-sustainable. CSR is voluntary, and it is therefore difficult to quantify the success towards social sustainability.

Deducing from literature review, benchmarking is a key challenge to structuring sustainable criteria for evaluating of contractors. This is even more complicated due to tangible and intangible stakes among stakeholders and the implications on project performance.

By applying cause-and-effects model for public sector benchmarking problems by Palaneeswaran and Kumaraswamy (2000), challenges of benchmarking criteria for selecting contractor for PPP infrastructure projects in Nigeria are discussed as follow:

7.3.1: Culture Clashes

Apart from 'ownership' being used as the key attribute in classifying construction contractors as MCC and LCC, culture is found to play a significant role. CCECC is leading MCC in Nigeria. An ethical stance by an organisation may be for economic gains and risk management measures. The low ranking of Chinese global business by the transparency international system (Okonjo-Iweala and Osafo-Kwaako, 2007) may suggest that cultural ethics by CCECC may be economic inclined. Culture poses a barrier to benchmarking strategy that would support and promote social sustainability in SID.

7.3.2: Internal Constraints

Unlike developed economies, there is no enforceable law and regulation for private sector to uphold social values in public infrastructure delivery. The ICRC is strict on economic returns, regardless of how resources are sourced. Prospects of employment creation in construction supply chain have not been optimised. The internal constraint is a driver for a no long-term value appraisal during decision making process.

7.3.2.1: Framework Agreement

Since infrastructure investment is an ongoing issue, it is concluded that MDAs would benefit from framework agreement with the leading construction contractors. Framework agreement is practicable with a client that aimed at commissioning projects over period. The contract documents would describe contract conditions for both pre-construction activities and construction phase. Contractor, as well, can provide risk adjustment mechanism. A framework can deliver benefits that include:

1) *Support from the local due to openness*
2) *Reduction in transaction costs*
3) *Continuous improvement*
4) *Better social values*
5) *Economic growth*
6) *Time and cost saving in contract awards due to no need for neither re-advertisement nor re application of selection criteria*

More importantly, frame working promotes cooperation among stakeholders and working environment that is needed to support continuous improvement. This would facilitate the actualisation of NEEDS agenda. There is a need for commitment from the government in commissioning capital projects and security to make local production more competitive. The introduction of free trade zone in Lagos is a positive development to attract multinationals in local production.

7.3.3: Resources Conflicts

The creation of the ICRC was to improve infrastructure delivery through private finance. Lack of funds is still a critical barrier for MDAs. Government agents are always at the weak end during contract formation. This is deduced on the fact that the motif of government on partnering is to transfer a significant risk to private entity.

7.3.4: Ambiguity in Value Definition

The challenge of lack of a generally accepted definition of VfM in the literature could provide an insight to the current trend of VfM appraisal in Nigeria PPP. The generally applied criteria for contractors' evaluation are underpinned by financial capability and past performance and reputation records. These are generic criteria in the conventional lowest price concept.

Lack of consistency in best VfM criteria is noticeable in the literature. From research conducted by Li et al. (2005), social support was stressed critical success factors in the evaluation of PPP projects. More recently, Yuan, et al. (2009) discussed a framework for a successful PPP best VfM.

'Content removed due to copyright restrictions'

Figure 7-1. Processes and factors in PPP projects
Source: Yuan, et al. (2009)

In figure 7.1, social sustainability is not considered as a critical need. While the need for more infrastructures in public domain is often the trend, little emphasis is placed on the supply chain, which is critical to social sustainability. It should be acknowledged, however, that little attempt, if any has been devoted to DC on sustainable evaluation criteria. Due to the established framework and legislations in developed economies, little emphasis is required on social procurement during contractors' selection for infrastructure projects.

7.3.5: Data Inadequacies

To date, there is no comprehensive data to serve as a datum base upon which sustainable performance of infrastructure procurement in Nigeria can be reviewed periodically for further improvement. Though there are list of published infrastructures in ICRC to corroborate milestone of PPP. No other data is available regarding success on social development, such as job creation linkage positive impact on the growing of construction supporting industries. Missing or lack of data on sustainable performance of PPP is a general setback in DC where information about PPP is often made confidential.

7.3.6: Lack of Relevant Models

There is no model that is specifically developed to guide the integration of social attributes to the contractor pre-evaluation process in Nigeria. As discussed in chapter five (research methodology), there is no generally accepted list of criteria to gauge sustainability of contractor during evaluation process in the literature. Following an extensive literature review on generally applied criteria, 55 important criteria for pre-evaluation of contractor were deduced. First, it is observed that generally, the identified criteria were underpinned with TBL of sustainability. In each of the reviewed journal, a specific dimension of SD is often investigated. Hence, no study attempted to integrate a holistic sustainable criterion. These criteria were

reduced to 16 after multicollinearity issues were solved. They formulated critical selection variables, which were modelled to five components, considering their latent dimensions. Combining with 'alternative' cluster, the value of the cluster of criteria obtained from 'normalized by cluster' of *Super Decisions* software is shown in Table 7.1.

Table 7-1 Nodes priorities explained

Cluster	Node	Normalised by Cluster		Limiting		
Alternative	MCC	0.63764	64%	0.154303	15%	**24%**
	LCC	0.36236	36%	0.087687	9%	
		1	**100%**			
Social Integration	S1 Coop	0.17365	17%	0.029856	3%	**17%**
	S2 Empl	0.36714	37%	0.063123	6%	
	S3 CSR	0.11161	11%	0.01919	2%	
	S4 Welf	0.3476	35%	0.059763	6%	
		1	**100%**			
Reputation and Integrity	L1 Insurance	0.33614	34%	0.028712	3%	**9%**
	L2 Safety	0.41345	41%	0.035315	4%	
	L3 Claims	0.25041	25%	0.021389	2%	
		1	**100%**			
Managerial Skills and Innovation	K1 Train	0.18338	18%	0.017986	2%	**10%**
	K2 Const. M	0.28895	29%	0.028341	3%	
	K3 Exp	0.32433	32%	0.031811	3%	
	K4 P Mgt	0.20334	20%	0.019944	2%	
		1	**100%**			
Asset	T1 Qual	0.27466	27%	0.083542	8%	**30%**
	T2 Avail	0.26002	26%	0.079089	8%	
	T3 Capit	0.46533	47%	0.141538	14%	
		1.00001	**100%**			
Environmental Conservation	E1 W Mgt	0.49814	50%	0.049023	5%	**10%**
	E2 Local	0.50186	50%	0.049389	5%	
		1	**100%**	**1.000001**		**100%**

In a simple term, the values under ‘normalised by cluster’ are value obtained column stochastic (please refer to Table 6:6 of computed weighted matrix, and chapter six). Value of elements in each cluster is sum to 1.

In summary, inference from table 7.1 provides the following information:

1) *Priority of variables within cluster*
2) *Priority of variables in the overall decision model*
3) *Priority of cluster of variables in the overall decision model.*

The next section of this chapter will elaborate on each of the cluster and the associated variables.

7.4: Assets

In ANP, all cluster of the decision network are treated equally. As revealed in the ‘limiting column’ of Table 7.1, ‘asset’ has the most influence in decision process with 30%. This is a myth in the growing of PPP globally in public sector. The findings further validate the goal of ICRC to seek for private entity. The three variables that make up the cluster are:

1) *Quality of human resources*
2) *Availability of equipment*
3) *Working capitals*

These three variables are the key factor of production in any successful project delivery. Though ‘availability of equipment’ and ‘quality of human resources’ has almost equal importance, ‘availability of working capital’ takes the highest priority. This is very logical in

global construction as required equipment and human expertise can be sourced globally with the available of funds to support quality infrastructure delivery.

From research findings, MCC potentially have the required capital capability for the acquisition of essential factors of production to deliver a successful project. Literature review further ascertained that LCC are large in number, but small in asset capability (Oyedele et al., 2015 Babatunde and Low 2013; Oluwakiyesi, 2011; Adams, 1997; Kaming et al., 1994).

It is also revealed in the literature that MCC often engaged on outsourcing of human resources mainly for economic gains. To date, there is no independent body that vet the quality and quantity of foreign workers that are employed by the multinationals in Nigeria. The driver for the current practice of value for money is centred on lowest cost (Taylor, 2007).

MDAs place high considerations on capability of contractor to support the finance of project delivery. Despite diverse theories on the essential criteria for contractor selection, project finance has been consistent in the literature (see Enshassi et al. 2013; Doloi, 2009; Palaneeswaran et al., 2003; Mahdi et al., 2002; Wong, 2000; Hatush and Skitmore, 1997).

Project finance by private entity equally favours BOT as core PPP (Carbonara et al., 2015; Al-Azemi et al. 2014; ICRC, 2012). Studies reflect that, though, indigenous construction contractors in Nigeria are large in number, their size and scopes of operation are considerable small (Oyedele et al., 2015 Babatunde and Low 2013; Oluwakiyesi, 2011; Adams, 1997; Kaming et al., 1994). Their capability is greatly hampered by financial constraints (Ofori, 2012), LCC are therefore, more much unlikely to compete effectively for the procurement of mega civil and building projects from MDAs.

7.5: Alternative Contractors

In this study, construction contractors are categorised to two, namely MCC and LCC. The division is informed based on the ownership, and form of operations. The cluster for the 'alternative contractor' represents 24% priorities. It is the second most important cluster. Further breakdown shows that the importance of MCC takes 15% while LCC is 9%. These values were obtained following the synthesis of the priorities of both MCC and LCC to the overall variables in the decision model.

7.6: Socio Integration

During pre-evaluation of contractor, social integration demonstrates a commitment towards social sustainability (Abidin and Pasquire, 2005). BOT procurement strategy is technically socially sustainable with a well-established structure that absorbs social values during decision process. From research findings, the components of social integration are:

1) *Cooperation with workers' union*
2) *Employment creation for locals*
3) *Contractor social responsibility initiatives*
4) *Employee well-being*

Data results have shown that MCC performed better in overall social integration. In practice, there is lack of empirical data to evaluate the degree of employment creation by the MCC in correlation with the opportunities that abound in construction supply chain. Oyeranti et al (2010) and Taylor (2007) argued that MCC have overturned 'local content' with little regard for socio-procurement. The trend has significantly promoted new ethnic concept as evident in segregation between local and foreign workers on construction site in Nigeria. This practice cast shadow on priority given to employee well-being and cooperation with workers' union. To date, there is no independent body that vet the quality and quantity of foreign workers that

are employed by the multinationals in Nigeria. The driver for the current practice of value for money is centred on lowest cost (Taylor, 2007). Du-Plessi (2007) had identified the creation of a capable and viable local construction sector as part of the essentials on the path of SC in Nigeria.

Within the 'socio integration' cluster on decision model, priority of employment creation of locals and welfare of workers are 6% apiece. This is followed by 'cooperation with the labour union, with 3% priority. CSR records 2%, representing the lowest priority in the cluster. This could mean that experts now hold a new view on CSR. CRS is a common mission statement for corporate entity in Nigeria to express their commitment to SD. The fact remains that CSR is a voluntary strategy, with no strict guideline for execution, adopted by the corporate organisation to demonstrate their commitment to the growth of business domain (Lompo and Trani, 2013). It is very unlikely to objectively quantify impacts of CSR in infrastructure decision process towards empowerment of the community. The data results further affirm the findings from extensive literature review no consensus view on the contributions of CSR towards environmental management and employment opportunities in DC (Lompo and Trani, 2013). It is difficult to quantify objective contributions of CSR towards environmental management and employment opportunities (Lompo and Trani, 2013).

7.7: Managerial Skills and Innovation

The clusters: 'managerial skills and innovation' and 'environmental conservation jointly occupy the fourth and fifth priorities with each having 10%. 'Reputation and integrity' are very close but with 9% to fall to the last ranking.

The cluster of 'Managerial Skills and Innovation' is aggregate of four variables, which are:

1) *Adequate training for operating process*
2) *Proposed construction methods*
3) *Experience in project of similar nature*
4) *Project management experience*

Managerial Skills and Innovation have two dimensions to modern construction practice. It allows for effective management of resources. Innovation demonstrates the ability to implement value engineering to reduce the cost while quality and profits are enhanced.

Managerial Skills and Innovation component is comprised of four decision criteria: 1) Adequate training for operating process, 2) Proposed construction methods, 3) Experience in project of similar nature and 4) Project management experience. Evidence has shown that continuity in business encourage firm to innovate. Construction client are also keen to select contractor with experience in project of similar project (Wong et al., 2000); Hatush and Skitmore, 1997a).

The preliminary research findings revealed that MCC take the leading role infrastructure delivery in Nigeria. Research findings further confirmed that MCC demonstrate superiority in all the attributes of managerial skills and innovation component. This can be attributed to their dominance over the past decades. With the continuity in business, they are able past knowledge gained from one project to another. The process promotes to innovate by deriving more effective construction methods.

Different views have been expressed on managerial skills and the ability to innovate among LCC. Idoro (2010) had argued that low productivity is eminent among local contractors due to factors such as skill deficiencies and shortage funds. Ilori, Nigerian Society of Engineers, hold different views on capacity building among local skills. Ilori was worried about the

marginalisation of LCC public infrastructure procurement which was attributed to prejudice. Ilori holds a stand that LCC is blessed with technical skills (Alimi, 2014) but with little opportunity innovate due to marginalisation.

7.8: Environmental Conservation

Sustainable infrastructure cannot be achieved exclusively of social and economic sustainability attributes. Construction has a bad reputation on environmental degradation, due to rely on natural resources for production, waste generation and embodied energy during production. Variables in environmental conservation cluster are:

1) *Environmental management certification*
2) *Local material sourcing*

In theory, environmental management certification demonstrates the commitment of construction firms to minimising environmental impacts of material and energy consumption during the entire infrastructural projects process. ISO 14000 series are related environmental management. A certified organisation is believed to have demonstrated compliance with applicable regulations on environmental matters. They have also developed a mechanism for minimising negative impacts of their processes on environment with continual review for improvement.

Under environmental conservation components, the two decision nodes are environmental management certification and local material sourcing. Vast studies on sustainable construction in Nigeria dare discussions on environmental impacts of construction activities. This encompasses material usage, embodied energy from material extractions, to transportation, process and energy consumption by building services.

Both environmental management certification and local material sourcing were considerably given the same priority of 5%. While local sourcing of materials helps to improve environmental performance, its social impacts include linkages with other economic sectors for job creation and knowledge management.

Despite the significance of local sourcing of materials in SD agenda, the priority is seemed considerably low. This may be due to concerns on the standard of available infrastructure. Competitive local production requires an effective and efficient infrastructures and services. Though there are significant improvements in transportation and communication systems, intermittent energy supply remains barrier in manufacturing sector. No significant improvement has been achieved in power sector.

The prospect of renewable energy has not been explored. With the gas reserve that is rated tenth in the world, and prospects for wind and solar energy, daily megawatts of electricity production fall below domestic demand (Taylor, 2007). Notable manufacturing industries, such as Michelin (tyre manufacturer) have either close business because of high cost of production resulting from non-sustainable power supply or relocate abroad to remain completive (Taylor, 2007).

7.9: Reputation and Integrity

A practical approach for a client to minimise of mitigate risk in project procurement is to search for a background information of the prospective contractors. Indicators for contractors' reputation and integrity in the literature include relationship with insurance companies, site safety records and claims and disputes history.

1) *Relationship with insurance company*
2) *Site safety records*
3) *Claims and disputes history*

Reputation and Integrity of contractor influence the degree of trust and trust they enjoy with the client. The rethinking construction (Egan, 1998) was commissioned due to persistent adversarial conditions among which resulted to high cost of construction. Form data analysis, potential contractor could demonstrate good reputation and integrity based their 1) relationship with insurance company, 2) site safety records and 3) records of claims and disputes history. Overall, respondents concluded that MCC have better reputation and integrity.

Relationship with insurance company, site safety records, and claims/dispute history are 3%, 4%, and 2% priority respectively. One of the key features of BOT is well structure risk management. It is less likely for BOT contractor to experience concurrent issue of claims. Concession-based projects are often subjected to renegotiation, which significantly altered projected project cost (Opawole and Jagboro, 2016a).

Extensive studies (Idoro, 2010; Oloyede and Tham, 2007; Kaming et al., 1994) have explored the practice of LCC. Among others, Oloyede and Tham (2007) noted delay, cost overrun, fluctuation in price of materials and fragmentation as key problems. Challenges with local contractors include lack of developmental strategy (Kaming et al., 1994); high construction cost (Ogunsemi and Jagboro, 2006); poor productivity and abandonment of projects (Fernz et al., 2013); low quality and safety performance (Oyedele, et al., 2015; Idoro, 2012; Idoro, 2010, Idoro, 2008; Oyedele and Tham, 2005). Frequent structural failures resulting in the lost life and properties (Idoro, 2010) could ascertain why LCC suffered bad reputation and integrity.

Poor site safety records and claims and disputes history of the LCC may be a driver for poor relationship with insurance company. As highlighted in chapter two, MDAs is very critical about the past performance and public image of prospective contractors.

However, the expressed viewpoints do not in any scale vindicate MCC from questionable unethical practice. Findings from the literature revealed that MCC have no regards to the local content (Taylor, 2007). The mode of operation of CCECC is outsourcing human and material resources from their country with no strategy for labour right, safety standard and global ethics in their host country. MCC have invested heavily in both commercial and political terms in Nigeria to solidify their economic ambition. They use their economic and political influences to gain significant preferential treatment during procurement process (Enweremadu, 2013; Chukwuemeka et al., 2011; Okonjo-Iweala and Osafo-Kwaako, 2007)). There is an evidence of the grant of the ‘right of first refusal’ to CCECC by MDAs (Taylor, 2007).

MCC exploits weak regulation system in Nigeria to maximise profit margin through tax evasion and compromised safety standard. Otusanya (2011) argued that multinationals in Nigeria engaged in various tax schemes such as offshore intermediary companies to claim loyalties or technical fees and under reporting of profit, to evade tax. On safety standard compliance, the findings of fire incidence in multinational owned company in Lagos, Nigeria, where many lives were lost revealed that it has become a common practice for local workers to be locked up in in the premise during production. From the global transparency ranking, China scores a considerably low ranking. In contrast, the leading MCC in Nigeria (CCECC) is Chinese state-owned company.

Notably, a statesman; Nelson Mandela, during a lecture session in British museum in 2000, as cited in IPIECA (2002, pp. 4) had boldly and cautiously declared that:

> *"If globalisation is to create real peace and stability across the world, it must be a process benefiting all. It must not allow the most economically and politically powerful countries to dominate and submerge the countries of the weaker and peripheral regions. It should not be allowed to drain the wealth of smaller countries towards the larger ones or to increase inequality between richer and poorer regions"*

The emerging global construction can only be productive where reputation and integrity are valued over unethical practices.

7.10: Initial Selection Criteria Ranking and Node Priorities Compared

During data analysis, descriptive statistics was used to rank the importance of the 16 selection criteria. These were the critical criteria obtained after multicollinearity in the web-based survey was resolved.

The results obtained from the descriptive statistics also correlate with the study by Fong and Choi (2000) where AHP was applied for contractor selection. Tendering price financial capability past performance experience and availability of resources are the most prioritised criteria. As reviewed in chapter three, AHP applies linear algorithm to decision making process; a technique that is like common statistical ranking process.

Study by Hatush and Skitmore (1997a) on criteria for contractor selection indicated that most common criteria considered in prequalification of contractors were financial soundness, technical ability, management capability, and health and safety performance.

The same dataset used in descriptive statistics was development to matrix, which was used for pairwise comparison matrix. At this point, the perception of judgement from experts was systemic as it weighed the impact of the dependencies among selection criteria. In Table 7.2, importance of criteria based on node priorities in ANP and descriptive statistics ranking are compared.

Table 7-2 Node priorities of criteria in ANP and descriptive statics ranking compared

	Nodes in ANP	Node priorities in ANP			Descriptive statistics ranking		
MCC	Multinational construction corporations	0.154303	15%	1st		***	
LCC	Local construction companies	0.087687	9%	3rd		***	
S1	Cooperation with workers union	0.029856	3%	9th		14th	
S2	Employment creation for locals	0.063123	6%	5th		11th	
S3	Contractor social responsibility initiatives	0.01919	2%	10th		13th	
S4	Employee well-being	0.059763	6%	5th		8th	
I1	Relationship with insurance companies	0.028712	3%	10th		15th	
I2	Site safety records	0.035315	4%	7th		10th	
I3	Claims and dispute history	0.021389	2%	10th		7th	
K1	Adequate training	0.017986	2%	10th		6th	
K2	Proposed construction methods	0.028341	3%	8th		9th	
K3	Experience in project of similar nature	0.031811	3%	8th		2th	
K4	Project management experience	0.019944	2%	10th		5th	
T1	Quality and quanity of human resources	0.083542	8%	4th		4th	
T2	Availabilty of equipment	0.079089	8%	4th		3th	
T3	Working and operating capitals	0.141538	14%	2nd		1st	
E1	Enviornmental management certification	0.049023	5%	6th		12th	
E2	Local material sourcing	0.049389	5%	6th		16th	
		1	**100%**				

From the above results, it can be validated that experts have completely different mind-sets while criteria are evaluated independently and when at least two criteria are compared to establish their importance. During the descriptive statistics ranking, for instance, local material sourcing was ranked 16th (the lowest rank). However, during the node priorities in ANP, the ranking is 6th. The change in ranking establishes the importance that is attached to local material sourcing by experts to achieve SID objectives.

It should be note that prevailing social economy in a geographical location may influence perception experts on the ranking of selection criteria. In a comparative study on challenges of construction, Ofori (2011) compared developed economies with developing countries.

Table 7-3 Difference between developed and developing countries with respects to major driving forces of construction

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Source: Adapted from Ofori (2011)

From 7.3, for instance, environmental conversation would be a less significant issue in developed economies. For instance, the established legislation and technology encouraging regulates modular construction, sustainable sourcing, and growth of renewable energy. These are issues of concern in DC.

7.11: The Applied Validation Techniques

Gass (1983) identified various techniques that can be used to validate model, and they include 1) animation, 2) comparison to other model, 3) face validation, 4) historical data validation, 5) sensitivity analysis Gass (1983). The application of the appropriate technique depends on the phenomenon under investigation and the type of model being used.

Each of the techniques can be used objectively or subjectively. As the name implies objectivism involves the use of statistical data or mathematical procedures. Subjectivism is a rationale that is often influenced by the researcher's viewpoints on the subject under scrutiny.

The rationale and the methodological process for the proposed SID model were discussed in chapter one and five. In chapter six, the model was implemented using data obtained from the

'pairwise comparison survey'. The two techniques used to accumulate evidence regarding the credibility and applicability of the model is sensitivity analysis and case study.

7.11.1: Validation of ANP

As earlier discussed in chapter five, the proposed SID model is three-interlinked phase, with the incorporation of ANP at the deductive phase. To validate ANP, two techniques have been adopted in the literature:

1) The computed predicted outcomes are compared with real life results. In this approach, a similar case with measures in an already known scale is first identified. When the ANP vectors are the same or very close to the known scale, then ANP model is concluded to be validated.
2) Sensitivity Analysis: It consists of changing the weight of each criterion (decision node) while observing the effect of the changes on the aggregate priority of the alternatives.

For this study, sensitivity analysis was applied for validation purpose for two reasons: the technique is proven to be well tested and widely applied in studies that are related to the implementation of ANP. The second rationale was the fact that the study brings a new theory of contractors' selection the procurement of public infrastructure in Nigeria. No similar study or measures of known scales were available in Nigeria to make comparisons with.

To perform 'what – if' sensitivity analysis on priorities of contractors is respect of the criteria (using 'Super Decisions Software, trial version), results of pairwise comparison data analysis (Node's priorities in Figure 6 8) was subjectively subjected to minor manipulations. During the first-round iteration of each of the 16 decision nodes, it was observed that 12 decision nodes (Coop, CRS, Welfare, Insurance, Training, Construction management, Experience, Project management, Quality, Availability, Capital, and Waste management) were not as sensitive as

'safety', 'employment', 'local material sourcing' and 'claim'. These four criteria were further analysed.

To perform sensitivity analysis, one asks what the decision would be if the priorities of the criteria were different. Procedure for sensitivity analysis in 'Super Decisions:

i. *Select a criterion from 'node for sensitivity'.*
ii. *Click on the parameter button and slide it to the right to vary its priority and observe how the priorities for the alternative change.*

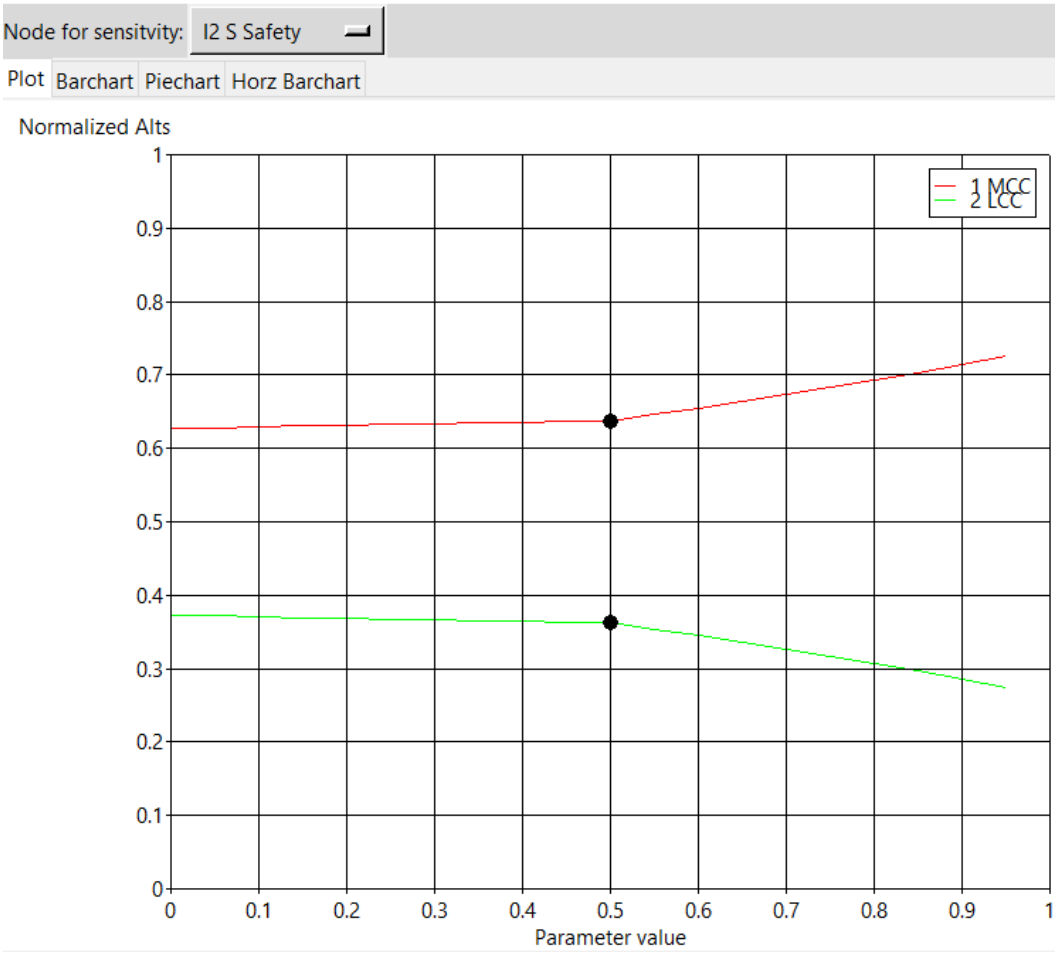

Figure 7-2: Sensitivity analysis for site safety

From Figure 7.2, Y axis = the ranking of contractors based on the actual computed priorities of criterion

X axis = Parameter value for sensitivity analysis. '0' indicates the actual priorities for the alternatives. As the parameter button is slide to the right, observations are taken on the patterns of priorities for alternative contractors.

Up to 0.5 parameter value, MCC enjoy slight improvement where LCC suffer slight less advantage. However, beyond the 'parameter value' 0.5, graph line for MCC was ascending while that of LCC was descending. The result implies the higher priority given to site safety, MCC will remain best option to deliver sustainable infrastructure.

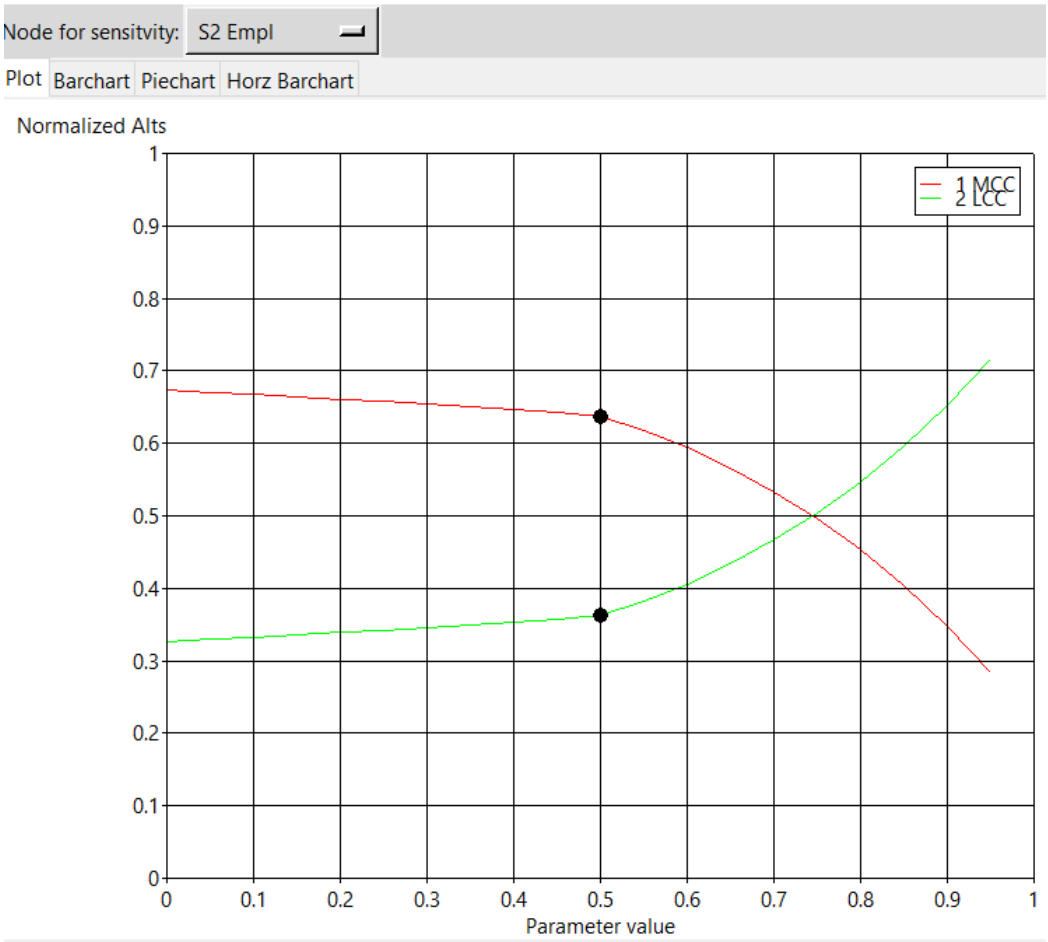

Figure 7-3: Sensitivity analysis for employment creations

From Figure 7.3, 'normalized alternatives axis (Y) re-affirm the ranking of MCC and LCC from data synthesis. Up to 0.5 parameter value, MCC suffers slight disadvantage where LCC enjoys slight advantage. However, beyond the 'parameter value' 0.5, graph line for MCC was

descending while that of LCC was ascending. The result implies the higher priority given to employment creations, LCC will remain best option to deliver sustainable infrastructure.

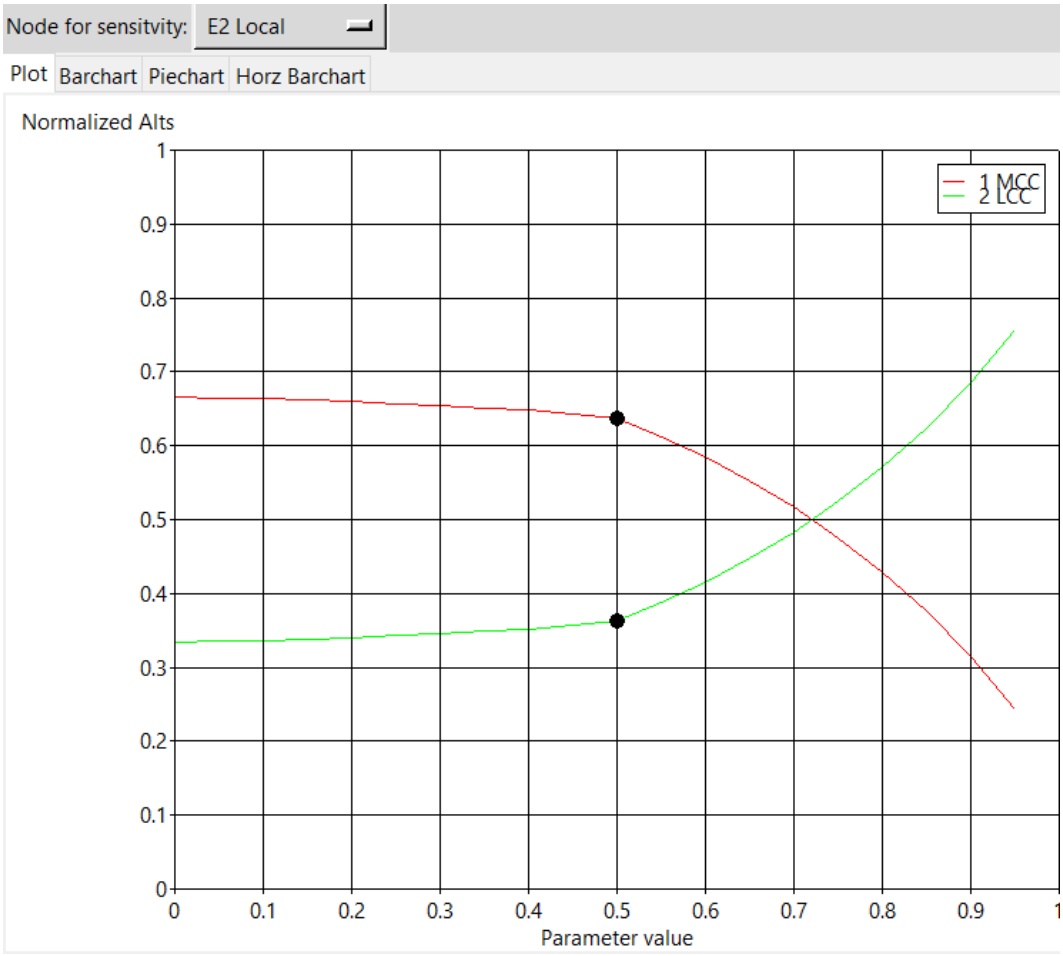

Figure 7-4: Sensitivity analysis for local material sourcing

The plot in Figure 7.4 is very similar to Figure 8.3. The 'normalized alternatives axis (Y) re-affirm the ranking of MCC and LCC from data synthesis. Up to 0.5 parameter value, MCC suffers slight disadvantage where LCC enjoys slight advantage. However, beyond the 'parameter value' 0.5, graph line for MCC was descending while that of LCC was ascending. The result implies the higher priority given to local material sourcing, LCC will remain best option to deliver sustainable infrastructure.

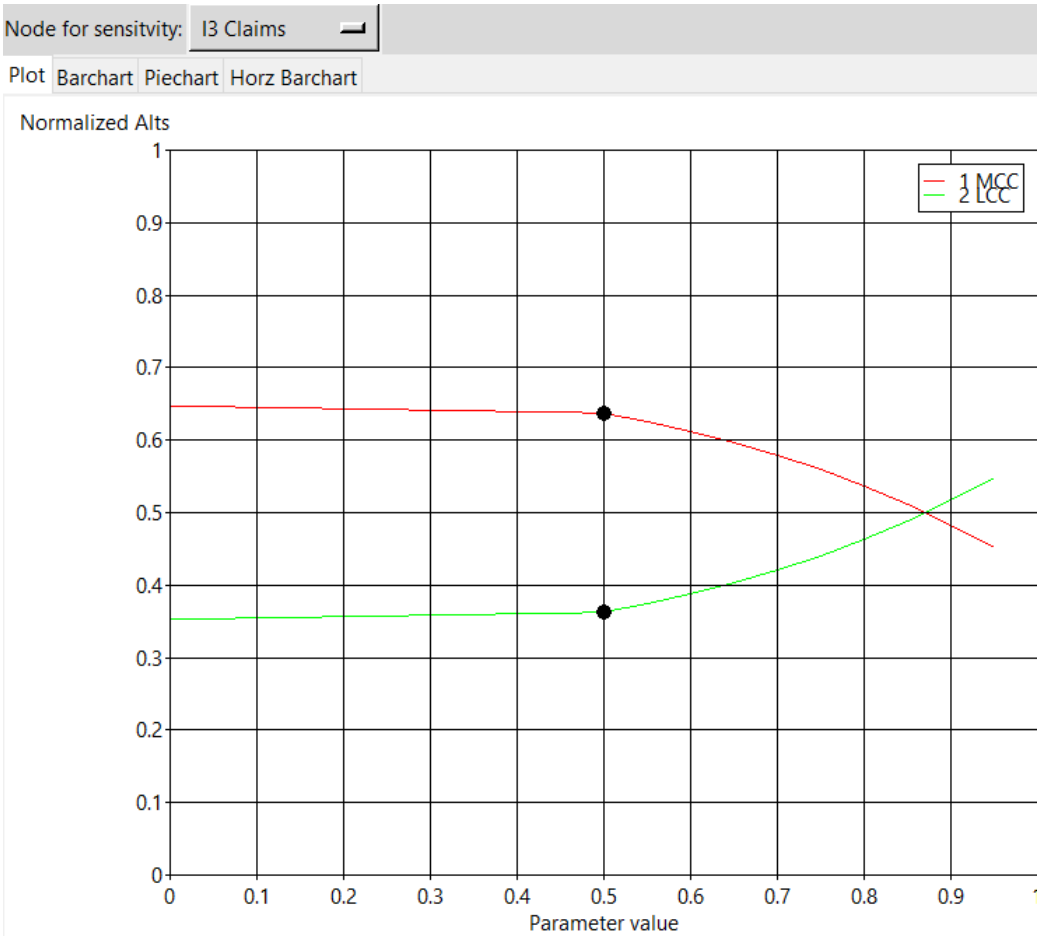

Figure 7-5: Sensitivity analysis for claims and disputes

From Figure 7.5, 'normalized alternatives axis (Y) re-affirms the ranking of MCC and LCC from data synthesis on claims and disputes. At 0 parameter value (research data results) MCC engage in claims and disputes than LCC. This is not unconnected to the fact that MCC engage in greater percentage of infrastructure projects. However, as the parameter value is adjusted to the right, MCC are less likely to engage in dispute while LCC are more like to engage in dispute. Beyond 0.5 parameter value, there is a better coordination by the MCC in respect of claims and dispute. This is not the case with the LCC with higher level of disputes and claims. It could be deduced that, on a long term, claims and disputes on contractual contracts with the MCC would be at the minimum. However, LCC is much likely to make huge claims on contracts on a long term. The sensitivity analysis has clearly shown the complexity and multi-criteria dimensions of pre-evaluation of MCC and LCC.

7.11.2: Validation of SID Conceptual Framework

The worked example for validating the application of the SID model in real life scenario involves the application to a case study of infrastructure project. The case study is illustrated below:

7.11.2.1: Summary of the Case Study: Abuja-Baru-Lokoja Rail Line

Project: Abuja-Baru-Lokoja Rail Line

Client: Federal Government of Nigeria (Federal Ministry of Transportation)

Cost: $3.9bn

Contractor: China Railway Construction Corporation Limited (CRCC)

Agreement: 15 per cent Nigeria equity and 10 per cent CRCC equity and borrow 75 per cent as SPV (Special Purpose Vehicle) from the Chinese Bank

To date, CRCC has executed 100% of rail projects in Nigeria, though concerns are often raised about the constitutional vetting PPP project's cost. There is ambiguity in contract breakdown: cost per kilometre of rail line, stations, coaches, other amenities.

Furthermore, critics are concerned of unregulated outsourcing of materials and human resources by Chinese firms in Nigeria. Among the key principles of PPP, as defined by ICRC is VfM, considering not only cost but also risks and service quality. Unsustainable infrastructure procurement is argued as contributing factor to unsustainable social development (source: https://punchng.com/breaking-fg-crcc-sign-3-9bn-contract-for-abuja-itakpe-railway/

7.10.2.1.1: Validation Process

The case study (Abuja-Baru-Lokoja Rail Line) used was a PPP project intended to validate SID model developed in this study. The validation is intended to appraise the sustainability of the prospective infrastructure and advise on potential area so of improvement. Though the case study illustrated a real-life project, it was considered hypothetical because of insufficient project information due to confidentiality of project procurement process. Findings from extant literature reveal one of the key challenges of PPP in Nigeria and DC, at large, is the high level of confidentiality that is applied to individual PPP projects.

Though project client is the Federal Government of Nigeria (Federal Ministry of Transportation), the project is regulated by ICRC as stipulated under ICRC Act of 2005. One of the key roles of ICRC is to provide guidelines and transaction support and building capacity in all the federal Government ministries, Agencies and Departments (MDAs) for project tendering, negotiation and contract execution. ICRC ensures that a robust fair, equitable, transparent, competitive, cost-effective process is developed for the selection, implementation and monitoring of sustainable PPP projects.

However, the available project information for the case study did not discuss comprehensive sustainable criteria for contractors' pre-qualification purposes. Summary of the project reflected on the pedigree of the selected contractor in terms of financial capability, bankability, and experience in similar projects as part of the criteria used for evaluation purpose. Public opinions on the proposed project reflected needs for social inclusion in selection process.

As highlighted in Figure 5.1 (Chapter 5), key phases in SID validation process are:

i. *Value appraisal*
ii. *Formulation of value Criteria*
iii. *Value analysis*
iv. *Application of ANP programme (Super Decisions Software)*
v. *Final decision, and*
vi. *Evaluation of results*

For validation purpose, therefore, the following assumptions are considered relevant to case study

i. *16 developed selection criteria in Table 7.4 is applicable*
ii. *The established relation among decision nodes within and between clusters, as established by the panel are assumed*
iii. *Both MCC and LCC are invited to tender*
iv. *Contractors are grouped broadly under MCC and LCC*
v. *Importance of contractors in respect to the developed weighting factors are influenced by the available data and educative assumptions*

Table 7.4 is the summary of the 2 broad categories of the alternative contractors for PPP infrastructure delivery for the proposed project. The 16 selection criteria developed in this thesis was subjected to modifications, based on the available project specific information and the application of educative assumptions, where necessary. The table described the alternative contractors based on the developed pre-evaluation criteria for SID.

Table 7-4: Summary of contractors for sustainable infrastructure delivery

	Selection Criteria	MCC	LCC	Remarks based on project information and literatures
1	Working and Operating Capitals	Excellent	Good	CRCC enjoys 75 per cent as SPV (Special Purpose Vehicle) from the Chinese Bank."
2	Experience in Project of Similar Nature	Excellent	Average	CRCC execute 100% of rail line infrastructure in Nigeria since 1990. Similar trend is recorded in broader countries in Africa
3	Availability of Equipment	Excellent	Average	CRCC is a specialised rail line contractor
4	Quality and Quantity of Human Resources	Very good	Good	Though concerns are often raised on the quantity, quality and human sourcing policy of Chinese firms in Nigeria
5	Project Management Experience	Excellent	Good	CRCC has a good track records in rail line infrastructure delivery
6	Adequate training for Operation Process	Very good	Average	Limited information available. It assumed that a specialised contractor will invest on staff training to remain dominant in the market
7	Claims and Disputes History	Good	Excellent	CRCC must be preferred contractor based on a long-term contractual relationship and better relationship with the client. Probability of claims from LCC is considerably very high due to lack of project experience
8	Employee Well-being	Good	Average	Limited information available. However, a contractor with continual workflow tend to care better for their work force
9	Proposed Construction Methods	Excellent	Average	A specialised contractor would develop better knowledge of construction methods over time
10	Site Safety Records	Good	Average	Though Chinese firms in Nigeria are culpable of site safety compromise
11	Employment Creation for Locals	Very good	Excellent	Outsourcing by Chinese firms remain a threat to job creation in Nigeria
12	Environmental Management Certifications	Average	Average	Though outsourcing of materials and human resources have negative environmental impacts, off site production minimise onsite waste generation
13	Contractor Social Responsibility Initiatives	Good	Average	Social responsibility initiatives are contractor's self-business-oriented policy that is difficult to quantify
14	Cooperation with Workers' Union	Average	Very good	Chinese firms in Nigeria are dominated with Chinese staff. Therefore, Workers' Union may be less significant
15	Relationship with Insurance Companies	Excellent	Good	Insurance companies are confidence based on their track record of infrastructure delivery
16	Local Material Sourcing	Average	Average	Key materials for rail construction are not available locally

Table 7.4 presents relative importance of each selection criteria in reference to contractors. The next phase in validation process was the application of ANP methodology and programme (refer to Chapter 4 for details). Appendix 3 provide detailed structure of questionnaire survey for ANP.

Table 7-5: Summary of contractors' options for the proposed project

	Selection Criteria	**MCC** (a_{ji})	**LCC** ($1/a_{ij}$)	**Remarks**
1	Working and Operating Capitals	7	1/7	MCC is very strong importance
2	Experience in Project of Similar Nature	9	1/9	MCC is extreme importance
3	Availability of Equipment	9	1/9	MCC is extreme importance
4	Quality and Quantity of Human Resources	3	1/3	MCC is moderate importance
5	Project Management Experience	7	1/7	MCC is extreme importance
6	Adequate training for Operation Process	7	1/7	MCC is very strong importance
7	Claims and Disputes History	1/7	7	MCC is extreme importance
8	Employee Well-being	3	1/3	MCC is moderate importance
9	Proposed Construction Methods	9	1/9	MCC is extreme importance
10	Site Safety Records	3	1/3	MCC is moderate importance
11	Employment Creation for locals	1/5	5	LCC is very strong importance
12	Environmental Management Certifications	1	1	Equal importance
13	Contractor Social Responsibility Initiatives	3	1/3	MCC is moderate importance
14	Cooperation with Workers' Union	1/3	3	LCC is moderate importance
15	Relationship with Insurance Companies	3	1/3	MCC is very strong importance
16	Local Material Sourcing	1	1	Equal importance

Note: a_{ji} is the weight at the upper diagonal of the matrix. The lower diagonal is filled using $a_{ji}=1/a_{ij}$

Contractors' rating in Table 7.5 were then evaluated by means of pairwise comparisons to determine the relative importance of contractors to selection criteria. The weighting of contractors in respect of selection criteria follows the methodologies of the fundamental scale for pairwise comparison (see Table 4.2).

Required data for the implementation of ANP are:

i. *Relative importance of criteria within cluster*
ii. *Relative importance of each criterion in reference to contractors*
iii. *Impact of alternatives on the importance of criteria*
iv. *Cluster priority with respect to the goal*

For validation purpose, all the above data template in the developed SID model shall remain constant, except 'relative importance of each criterion in reference to contractors', which shall be project specific information (see Table 7.5 for the case study under validation).

7.10.2.1 2: Results and Discussions

`The validation results in Figure 7.6 conforms the decision to award the proposed Abuja-Baru-Lokoja Rail Line Project to MCC. The weighing was 65% (MCC) to 35% (LCC) respectively. The results show that MCC will deliver value. LCC is rated considerably low in most of the selection criteria. From a real-life scenario, the case study demonstrates the applicability of SID model for the appraisal of the sustainability of proposed infrastructure project.

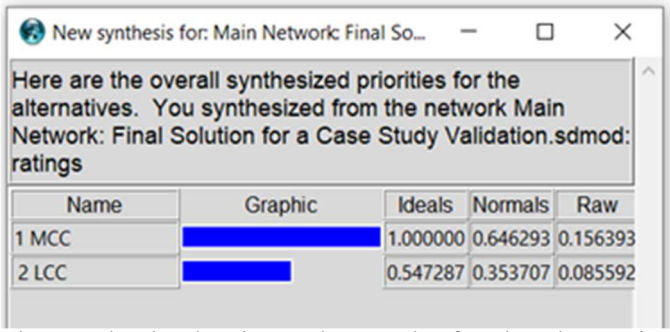

Figure 7-6: The synthesised values- the results for the alternative contractors

Figure 7.6 shows the network representation of the contractors' selection model for the proposed rail line infrastructure project. Detailed results of case validation are available in Appendix 6.

Sensitivity of each of the 16 criteria that were synthesised during selection process was further analysed. The most sensitive criteria are as follow:

1) *Cooperation with workers' union (Criterion S_1)*
2) *Employment creation for locals (Criterion S_2)*
3) *Claims and disputes history (Criterion I_3)*

Both 'Cooperation with workers' union' and 'Employment creation for locals' and nodes on Socio Integration cluster, while 'Claims and disputes history' is a node in Reputation and Integrity cluster. It can be deduced that sustainability of the proposed project could be further enhanced based on key decisions on sensitive criteria.

Virtually all judgement in infrastructure procurement is characterised with imprecision. Sensitivity analysis therefore useful to gain further insight on results influenced by possible changes in some criteria of the decision problem. Figure7.7, 7.8 and 7.9 respectively show the changes produced in contractors' preferences when the weight of the criterion S_1, S_2, I_3 are modified.

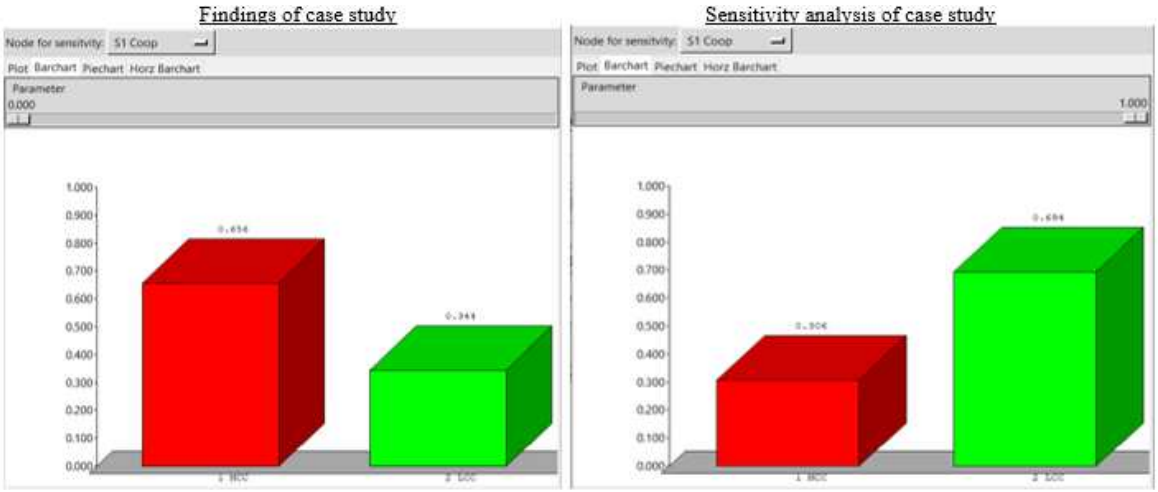

Figure 7-7: Sensitivity analysis of case study- Criterion S_1

From Figure 7.7, it is observed that as the weight of criterion S_1 (Cooperation with workers' union) increases, LCC tend to be valued option. It could be further validating the dominance of Chinese work force in Chinese owned corporations in Nigeria. Influences of workers union

tend to become weak as the work force are predominantly expatriates and they share common goals with the corporation.

Employment creation for locals

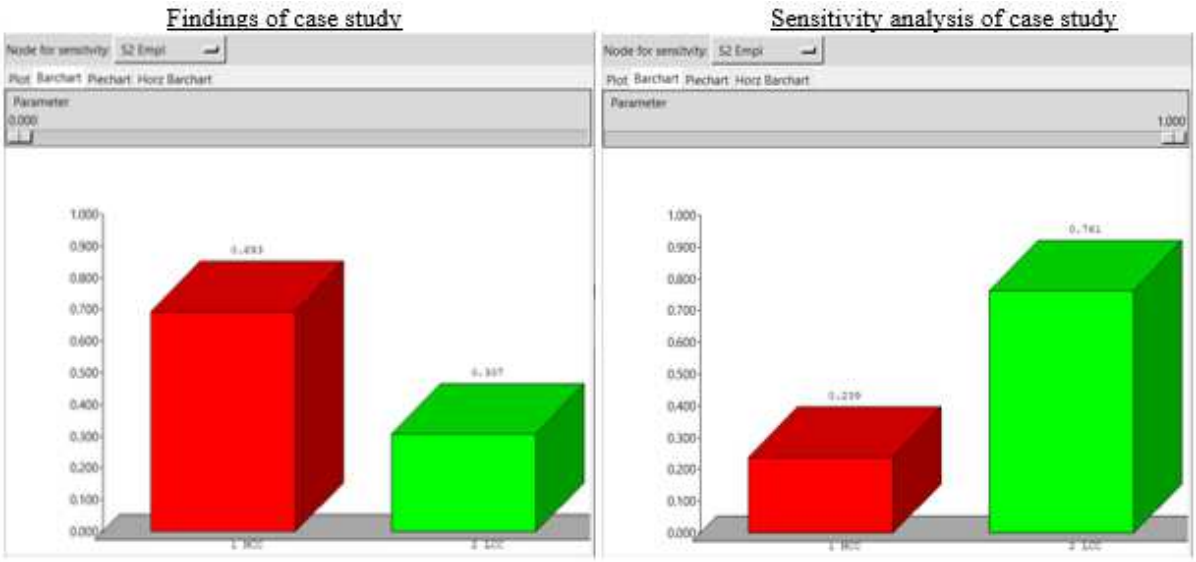

Figure 7-8: Sensitivity analysis of case study- Criterion S_2

Figure 7.8 show that the means of promoting employment creation for locals is to engage LCC. An effective work breakdown will clearly indicate the quality and quantity of human resources that are required for the project.

Claims and disputes history

Infrastructure project is associated with uncertainty Claims and disputes can be culpable or preventable. In general claims and disputes can have significant impacts on reputation and integrity among stakeholders. From data analysis, MCC make more claims than LCC. This can be understandable as MCC execute majority of the projects. Given 'claims and disputes' more priority, LCC will make even more claims. Other attributes, experience in projects of similar nature and construction methods will make MCC less liable to culpable claims and disputes.

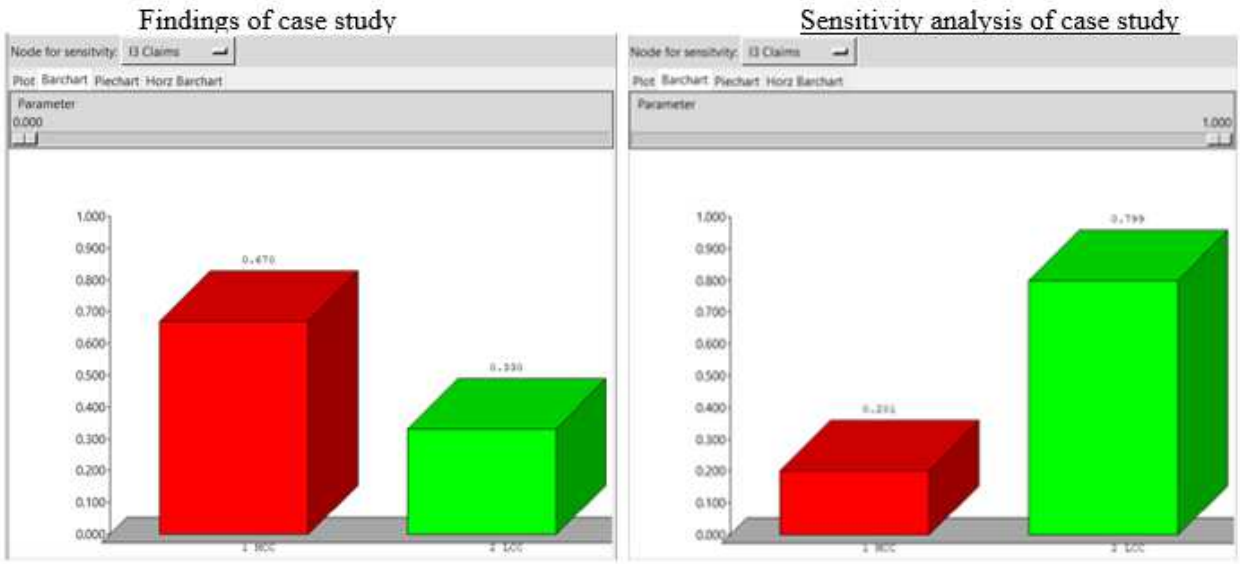

Figure 7-9: Sensitivity analysis of case study- Criterion I_3

In summary, there is a strong interlinkage between the 3 sensitive decision nodes. The more LCC is fully engaged in the delivery process, there is more like rise in claims and disputes.

Overall, sensitivity analysis conducted on the case study revealed key areas where further improvement would further sustain Abuja-Baru-Lokoja Rail Line. Substantially, the analysis further upholds key challenges faced in multicriteria decision making process.

Notwithstanding, the overall preference of MCC in the project, it could be deduced from sensitivity analysis the need for the engagement LCC in various specialities infrastructure supply chain to promote employment creation for locals. However, an effective management strategy must be initiated to manage preventable claims and disputes arising form LCC mode of operation.

7.12: Summary

The chapter discussed the findings of this research and their implications to SID. Achieving SID required benchmarking, through which interests of stakeholders were managed during pre-evaluation of contractor. Key divers of non-successful benchmarking were identified and discussed under 'culture clashes', 'internal constraints', 'resources conflicts', 'ambiguity in value definition', 'data inadequacies, and 'lack of relevant models. The developed decision model for was developed under six components, after the latent dimensions of the nodes in the model had been established. The comparison of descriptive statistic ranking of the selection criteria with the ranking obtained from the implementation of the ANP established a new theory. The actual importance of those pre-evaluation criteria can only be obtained after dependency among the criteria has been established.

Furthermore, LCC were more sensitive to three variables, 'local sourcing of material', 'employment creation for locals', and 'claims and disputes' during sensitivity analysis. The findings further confirm the need for the LCC to improve on their reputation and integrity.

In conclusion this chapter presented a validated SID model with the application Abuja-Baru-Lokoja Rail Line. Despite missing data due to high confidentiality in PPP project, educative assumptions were made where necessary, which were adequately reviewed by experts in infrastructure procurement in Nigeria. Ability of the SID model to effectively appraised a project-specific needs for further improvements were demonstrated.

CHAPTER 8 : CONCLUSIONS AND RECOMMENDATIONS

8.0: Introduction

This chapter presents summary of research, conclusion, and recommendations for further studies. The general introduction of the research was presented in Chapter One of the thesis, with the research aimed to develop framework criteria for contractor selection that Nigerian government could use to achieve value in the delivery of sustainable infrastructure project. Chapter Two provided a preview on sustainable development with special interest on social sustainability. This was followed with sustainable infrastructure in Nigerian concept. Chapter three elaborated on method procurement methods for capital project. Chapter Four presented research methodology while Chapter Five discussed conceptual framework and SID model. Chapter Six and Seven are data analysis and discussion of research findings respectively. The final Chapter was the concluding remarks and recommendations.

8.1: Achievement of Research Objectives

To achieve the aim of this study, five research objectives were propounded in Chapter One. Table 8.1 provides summary of the objectives and the methods applied to achieve them and the relevant chapters for references.

Table 8-1: Methods used to achieve the research objectives

	Objective	Method of Achievement	Chapter
1	To investigate current contractors' selection process for infrastructure projects	-Literature review	2
2	To evaluate key procurement methods that can be used for capital projects	-Literature review -Questionnaire survey	4 & 5 7
3	To analyse contractor's selection criteria that support sustainable infrastructure delivery and best value for money	-Literature review, -Questionnaire survey and -Data analysis	2, 3 6 & 7
4	To determine the level of application of sustainable criteria during pre-qualification of contractors for PPP contracts (including ranking these criteria in order of importance)	-Literature review -Data analysis -Discussion of research findings	2, 3, 6 & 7
5	To develop and critically evaluate a novel sustainable infrastructure delivery framework that could be used during pre-qualification stage for contractors involved in PPP projects	-Literature review -Questionnaire survey -Model design -Testing of developed model using sensitivity analysis	2, 3, 5, 6, & 7

8.1.2: The Current Contractor Selection Process for PPP Projects in Nigeria

The first research objective was to investigate current contractor's selection process for PPP infrastructure projects in Nigeria.

The contractors' evaluation process for infrastructure projects is exclusively based on competitive bidding and competitive negotiation bidding. Though there is dearth of information from the literature, however, with the major capital projects being procured through specific set of contractors, it could be deduced that competitive negotiation bidding is a predominant strategy. Competitive negotiation bidding is used in the literature for infrastructure that involves high skills and expertise to delivery successfully. The option is used to negotiate with a very few contractors with a proven track record in the delivery of such projects. Major transportation infrastructure (road, rail, bridges) are anchored in Nigeria by CCECC. CCECC is the one of the largest construction corporations in the world, and with controlling shares in construction project in Nigeria and the entire Africa. They also provide

loan facility and ‘trade by barter’ option in construction contract. Their mode of business makes them a best fit for the government economic reforms policy.

As part of loan grant pre-requisite by the World Bank for infrastructure projects, government through MDAs must apply competitive bidding to achieve most competitive price for the project. The request for transparency in procurement process by the World Bank also mandated a CPAR) as a prerequisite of lending terms. The assessment intended to gauge the strengths and the weaknesses of the applied procurement strategy for public procurement. On a positive note, the development provided a framework for the enactment of a public procurement law and the establishment of institution with the responsibility for issuing policy direction on public procurement.

According to the Nigerian BPP, the principal hallmarks of proficient public procurement, as proscribed by BPP were economy, efficiency, fairness, reliability, transparency, accountability, and ethical standards. These essentials were like the methodology for construction procurement British standard (BS ISO 10845-1:2010). Meanwhile, social procurement was not thoroughly appraised as applicable to international procurement. Chapter five elaborated on social procurement and it was revealed that the challenge of the integration of social values in capital project delivery was a general concern in DC.

8.1.2: Contractor Selection Criteria that support SID and Best Value for Money

The second research objective was to undertake in-depth literature survey and explore contractor selection criteria that support sustainable infrastructure delivery. The literature review conducted in Chapter five and six revealed that there was no consensus on the criteria for contractor that deliver sustainable infrastructure. With the research goal in mind, extensive literature review was conducted to identify relevant criteria. Overall, 55 criteria were identified. Since the study intended to synthesise the criteria to predict contractor that deliver sustainable infrastructure, 55 criteria were considered enormous. Besides, it established in the literature that, in a study of this nature, multicollinearity issue in data set is inevitable. This necessitated questionnaire survey conducted in Chapter Seven that sought the opinion of construction experts on the importance of the each of the 55 criteria in the context of sustainable contractor selection process. The analysis of the data using FA resulted in the criteria being reduced to 16 after multicollinearity issues was resolved. With the data set subjected to Principal component analysis for extraction purposes and rotation method of varimax and Kaiser Normalization, the criteria were grouped to five components. After their latent constructs had been established, the five criteria clusters for the selection of contractor that deliver sustainable infrastructure were labelled as:

1) *Environmental Conservation*
2) *Managerial Skills and Innovation*
3) *Reputation and Integrity*
4) *Asset*
5) *Social Integration*

The 5 components give insight to the decision makers on key dimensions during contractors' pre-evaluation for public infrastructure procurement through PPP.

8.1.3: Key Procurement Methods that can be used for Capital Projects

Extensive literature review showed that procurement methods that could be used for procuring capital projects are enormous, and they include traditional, management contracting, construction management, design and build and PPP. Traditional method was once popular among public client, though it is adversarial in nature, construction risks are sorely bored by the client. In pursuant of VfM, MDA embraces various streams of PPP, including (BOT) - Build Operate Transfer; RBOT - Rehabilitate/Build Operate Transfer; LPM - Landlord Port Model" for the Nigerian ports in line with the ports reform programme; RLOT - Rehabilitate, Lease, Operate and Transfer.

Meanwhile, BOT is the common procurement strategy being used to procure the facilities by MDAs. Pre-evaluation of contractors for BOT projects is a complex decision-making process in many facets, considering the common interests of government agencies to transfer absolute project risks to the private entity, the goal of economic returns by the investors, and the expected social benefits from the project by the community. Corporation and well-being of the community is very paramount because the sustainability of the infrastructure delivery is not complete without their long-term commitment to maintenance surcharges.

8.1.4: Level of Application of Social Criteria during Pre-Qualification of Contractors in PPP Contracts

Following extensive literature review, no data could verify the inclusion of social attributes during pre-evaluation of contractors. This was attributed to ill-definition of VfM, focusing on the tangible attributes of infrastructure delivery. A framework of criteria for pre-evaluation of contractors is also developed to complement the established contractors' evaluation attributes that is mainly undermine by tangible attributes.

8.1.5: A Novel Framework and Analytical Model for Contractor Selection

The fifth objective was to propose a novel framework and analytical model that predict sustainability of selected contractors for the delivery of constructed facilities. The model was developed in chapter five, following inferences that were drawn from the previous chapters.

The proposed SID model is influenced by the work of Checkland and Scholes on SSM. The model is a three-phased interlinked framework. At the deductive phase of the model is the incorporation of ANP. The technique allows for the quantification of both tangible and intangible variables during contractors' evaluation process. A case study was applied for the validation of the developed SID model. It further demonstrates ability of the model to effectively appraise project's needs at prequalification phase to deliver optimum VfM.

8.2: Experts Opinions on Construction Benefits

Construction benefits were explored from systemic view to have broad understanding of construction values. The benefits were classified as:

1) *Direct effects: Physical infrastructure*
2) *Multiplier effects: Job creation*
3) *Wider economic benefits: support for other industries*
4) *Higher quality construction: ability to compete at international level*

The above was modified to questionnaire that sought the level of agreement of the respondents on how the attributes support social economic development. The mean of the descriptive statistics showed that 'job creation' had the highest score of 4.09. Support for supporting industries had a score of 3.88, slightly higher than 'physical infrastructure' (3.74) and 'compete at international level' (3.83). To evaluate the impacts of value management in infrastructure procurement on socio-economic development, two hypothesises were put forward to evaluate impacts of value management in infrastructure procurement on socio-economic development.

Job creation

- *H_0: Public infrastructure procurement does not contribute significantly to job creation*
- *H_A: Public infrastructure procurement contribute significantly to job creation*

Construction supporting industries

- *H_0: Public infrastructure procurement does not enhance the growth of construction supporting industries*
- *H_A: Public infrastructure procurement enhance the growth of construction supporting industries*

The hypothesis test failed to reject the null hypothesis. It was concluded that construction benefits in Nigeria has not contributed significantly to n socio-economic development.

8.3: Sensitivity Analysis of Selection Criteria

Though the evaluating results predict MCC to deliver most sustainable infrastructure, results sensitivity analysis affirmed that best value in infrastructure procurement could only be achieved through the integration of local skills in construction supply chain and support for the growth of local construction supporting industries.

8.4: Conclusion

The primary aim of this research, to develop a framework for contractors' selection that MDAs in Nigeria can use to achieve value in the delivery of sustainable infrastructure project, has been achieved. The conceptual framework for selecting contractors was presented, discussed and validated in the thesis using proposed Abuja-Baru-Lokoja Rail Line in Nigeria.

Sensitivity analysis clearly demonstrate the need for local material sourcing and employment creation as the integral for SID. Consequently, continual inclusion of LCC put site safety at risk and rise in claims and disputes. Preference of MCC for outsourcing could or be associated to non-availability of materials, locally. Lack of infrastructure and amenities contribute to high

cost of local production and justification for exportation. Though, foreign skills are often required in the specialised infrastructure projects delivery, MCC often explore their strong capital influences and weaknesses in regulatory framework of the host nation to promote socio-economic development of their home nation.

There is no regulatory framework on the quantification of the required skills in construction and long-term local skill acquisition strategy. Both MCC and LCC remain exclusive in infrastructure procurement process to sustain social development and improve environmental impact of infrastructure delivery.

The benchmarks of the sixteen contractors' selection criteria developed in this research have been validated and they can be used for pre-qualification purposes. This would support a better decision which would improve the overall sustainability of infrastructure projects.

8.5: Contributions to Knowledge

Overall, the significant achievements of this study in terms of contribution to knowledge has been analysed under contributions to theory and decision-making process.

8.5.1: Contributions to Theory

There is growing concern for poverty eradication in DC. The continual dominance of DC by the most economically and politically powerful countries would remain a barrier to creating real peace and stability across the world (IPIECA, 2002). The literature review revealed there is growing need to exploit construction values towards eradication of extreme poverty and hunger in DC.

The study derives a theory for the definition of sustainable infrastructure delivery, which goes beyond the procurement of physical structure from a sustainable contractor. The long-term maintenance of the constructed facilities is a function of the ability of the end user to provide finances for repair and maintenance. When the public is empowered during delivery process, they will be substantial to provide technical and financial resources to maintain the facilities during their useable life.

8.5.2: Contributions to Decision-Making Process

1: The study showed that implementation of SID model by MDAs would foster better transparency and harmony among key stakeholders in public procurement

2: The study highlighted lack of empirical data based on which the performances of local contractors could be gauged. There has been gross prejudice against the capability of the local skills. Percentage of culpable events have not been effectively evaluated against the number of contractors

3: No empirical data to confirm acclaimed gross gap in local skill supply

4: The guiding procurement policy for MDAs is economic in word in the definition and interpretation of VfM in public procurement. The interpretation of the concept influences the public funding of public infrastructure strategy cost reduction as it failed to elaborate on social value and delivery mechanism

5: No independence body to vet the quality of human resource being outsourced by the multinational corporations in compared to available local workforce

6: The system fails to appreciate the significance of construction sector as a driver for the revitalisation of broader economic sectors through material demand and request for specialised skills

It has also been revealed that evaluation of criteria from components' perspective give more realistic real-life appraisal than individual criterion appraisal.

8.6: Limitations of this Research

The research carried out in this thesis is novel for its relevance to poverty eradication strategy in DC. The findings from the study are invaluable to MDAs and relevant construction stakeholders, helping them to incorporate social procurement to the contractors' assessment for public infrastructure. However, there limitations associated with this study in terms of its conduct and scopes are outline below:

1: Although numerous publications have been made on sustainable construction, none has been made on a sustainable infrastructure delivery, focusing on the integration of social, economic and environmental values during contractor selection. Hence there is limited information on this topic.

2: The research highlighted the important role construction industry could play in social-economic development in Nigeria. However, the empirical trends of the contribution of construction activities to employment creation could not be ascertained.

3: The study identified the importance of local sourcing of construction materials to promote construction values. Despite significant investment by the public on constructed facilities over the past decades, there is no up to date empirical data to

gauge cost-effectiveness of local production. Inferences were only drawn from literature review

4: The research validation was limited to sensitivity analysis. Further validation methods could be engaged to establish the effectiveness and efficiency of the model

5: Primary data was obtained mainly via questionnaire survey. A study of this nature would benefit further from focus group through seminars. Further study could be carried with the adoption of qualitative data collection methods

8.7: Recommendations for Future Research

Considering the limitations that were outlined in previous section, some of the key relevant issues that can benefit from further research are recommended below:

1: A timeline research on the contribution of infrastructure procurement to social development in Nigeria

2: There is need for a comparative study on the locally produced construction materials and the imported materials, taking to consideration the social and environmental factors.

3: A further study can be conducted to validate SID model, using questionnaire that had been developed for the purpose in this study

4: The study was grossly applied quantitative approach. A further study would benefit from using qualitative techniques such as interview and Delphi for data collection.

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Appendix 1: Related Publications

1.1: Published Journals

1. Arowosafe, O., Oduyemi, O., Ceranic, B. and Dean, A. (2018) Sustainable infrastructure delivery in Nigeria: implementation of the analytic network process for contractor selection. Sust. Build. 3, 5
2. Oduyemi, O., Okoroh, M. I., Fajana, O. S. and Arowosafe, O. (2018) The need for economic performance measures for life cycle costing of sustainable commercial office buildings. Journal of Facilities Management, Vol. 16 Issue: 1, pp.54-64

1.2: Ongoing Journals

1. Arowosafe, O. and Ceranic, B. (2019) The growing needs for contractor selection criteria for build-operate-transfer (BOT) facilities in Nigeria. Construction Management and Economics (to be submitted in Nov 2019)
2. Arowosafe, O. and Ceranic, B. and Okoroh, M. (2019) Sustainable infrastructure delivery: a systemic pre-qualification model. Journal of Building Engineering (to be submitted in Dec 2019)

1.3: Conferences

1. Arowosafe, O., Ceranic, B. and Dean, A. M. (2015) A sustainable infrastructure delivery model: Value added strategy in the Nigerian construction industry. Procs 31st Annual ARCOM Conference, 7-9 September 2015, Lincoln, UK, Association of Researchers in Construction Management, 1229-1238
2. Arowosafe O., Ceranic B. and Dean A. (2015) Construction costs and value management: study of multinational practices in Nigeria. COBRA 2015 (RISC) Conference Sydney, 8-10 July 2015
3. Arowosafe O., Okoroh M. and Dean D. (2014). Forecasting sustainable infrastructure delivery in Nigeria beyond 2015. World Engineering Conference on Sustainable Infrastructure (WECSI) Abuja, Nigeria, 2-7 November 2014
4. Arowosafe O., Okoroh M. and Dean D. (2013) Application of ISO14001 for composites waste management. Sustainable Building and Construction Conference (SB13), Coventry University, 3-5 July 2013

Appendix 2: Sample survey questionnaire and accompanying cover letter

Dear Sir,

My name is Oluwumi Israel Arowosafe, and I am currently undergoing PhD in Value Management in Nigeria construction industry. Value for money (VFM) in the delivery of BOT projects has been achieved through a competitive bidding process among contractors (broadly classified in this study as (multinational construction corporations (MCC) and local construction contractors (LCC). The views on the success of the strategy among stakeholders remain divergent. The contributions of contractor selection for constructed facilities towards sustainable development, therefore, justify further research.

This is your chance to share your views on the attributes of contractor that deliver best value for the procurement of public constructed facilities in Nigeria. The questionnaire should take around 20 minutes to complete.

In compliance with the research ethical considerations, your feedback will be completely anonymous and used solely for academic purposes; it cannot be linked with your personal information in any way.

The success of this research depends entirely on your voluntary co-operation, and I do hope that you will be able to take part. It would be of immense favour if the survey links is shared with your professional colleagues.

Please tick this box if you are interested in receiving findings of the survey and the research

☐

Thank you very much for your time and participation.

Kind regards

Oluwumi Arowosafe (ICIOB)
Doctorate Research Student
Faculty of Art, Design and Technology
University of Derby, Markeaton Street, Derby
DE22 3AW
E mail: o.i.arowosafe@derby.ac.uk

1: Background Information

1.1: Please confirm your discipline:

	Civil Engineer
	Quantity Surveyor
	Architect
	Construction Manager

1.2: Your field of work:

	Education
	Government agency
	Local construction company
	Local manufacturing company
	Foreign construction company

1.3: Your highest educational qualifications:

	PhD
	MSc/March/MEng
	BSc/BArch/BEng
	Higher National Diploma
	National Diploma

1.4: Your current position:

	Manager
	Procurement officer
	Lecturer
	Team leader
	Member of staff

1.5: Organisation structure?

	Construction
	Manufacturing
	Procuring
	Consulting
	Education

1.6: Years of experience?

	0-5
	6-10
	11-15
	More than 15

1.7: Please state degree of your awareness of government partnership arrangement in the procurement of civil and building projects in Nigeria

	Very aware
	Aware
	Somewhat aware

2: Sustainable Contractor Selection Criteria for Public Infrastructure

Please rate your opinion on a 5-point Likert scale on the following criteria in term of their importance in the selection of contractor for the delivery of sustainable public infrastructure

Criteria	**Extremely important**	**Very important**	**Satisfactory?**	**Low important**	**Not at all important**
	5	**4**	**3**	**2**	**1**
1-Working and operating capitals					
2-Bank arrangement guarantee					
3-Yearly turnover history					
4-Employee wellbeing					
5-Taxes clearance					
6-Experience in project of similar nature					
7-Suitability of equipment to project capacity					
8-Availability of equipment					
9-Training and skills level of craftsmen					
10-Proposed construction methods					
11-Project control and monitor procedures					
12-Site organisation					
13-Construction progress reporting systems					
14-Project management experience					
15-Knowledge of outsourcing					
16-Knowledge of local environment					
17-Cooperation with workers' union					
18-Knowledge of labour law					
19-Ability to deal with unanticipated problems					
20-Quality and quantity of human resources					
21-Quality and quantity of managerial staff					
22-Current work load					
23-Willingness to update technology and share risk					
24-Ability to complete on time					
25-Work quality achieved in similar work					
26-Length of time in business					
27-Relationship with sub-contractors					
28-Relationship with suppliers					
29-Relationship with insurance companies					
30-Relationship with local authority					
31-Claims and disputes history					
32-Comparison of client's estimate with tender price					
33-Cost control and reporting system					
34-Safety of machineries					
35-Adequate training for operating process					
36-Personal protective equipment					
37-Culture fit with host community					
38-Site organisation rules and policies					
39-Contractor familiarity with geographic area					
40-Site safety records					
41-Employment creation for locals					
42-Local material sourcing					
43-Knowledge transfer					

44-Contractor familiarity with local suppliers					
45-Contractor familiarity with local labour					
46-Contractor social responsibility initiatives					
47-Operation costs					
48-Maintenance cost					
49-Deconstruction and replacement					
50-Environmental management certification					
51-Waste and recycling					
52-Control of pollution and hazardous substances					
53-Reduction in energy usage					
54-Reduction in water usage					
55-Selection and use of materials					

3: Benefits of Construction

The benefits of construction can be summarised in four clusters. How much do you agree with the following statements? How do you agree with the following attributes of construction sector towards supporting social economic development?

Variables	**Attributes**	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
		5	4	3	2	1
Higher quality construction	strive towards competing globally					
Wider economic benefits	High performance in construction supporting industries					
Multiplier effects	Significant improvement in job creation					
Direct effects	Milestone in infrastructure delivery					

Appendix 3: Pairwise Comparison Questionnaire

To Whom It May Concern

Dear Sir Madam

RESEARCH ON BUILD-OPERATE-TRANSFER (BOT) CONTRACTORS' SELECTION PRACTICE IN NIGERIA

As you effectively participated in the first-round questionnaire which criteria in term of their importance in the selection of contractor for the delivery of sustainable public infrastructure, you are hereby again asked to evaluate the critical criteria identified by assigning weights through pairwise comparison. This complies with the methodology for the validation of the predictive model developed in contractor selection for BOT contracts in incorporating integrated sustainability indicators to tender's pre-evaluation process when selecting civil and building contractors. Detailed of the critical selection criteria identified from the first-rough questionnaire, after multicollinearity issues had been resolved are given below.

The research will help toward improved sustainable contraction evaluation and selection process, which would benefit economic, socio and environmental values.

Information obtained from you will be used strictly for academic purpose. If you would like any further information about this study, please let me know.

Kind regards

Oluwumi Arowosafe (ICIOB)
Doctorate Research student
Faculty of Art, Design and Technology
University of Derby
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DE22 3AW
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The scenario: A hypothetical decision-making network

The proposed structure taken as a decision-making network is a hypothetical contractor selection for public infrastructure in Nigeria. MDAs are charged with the delivery of infrastructure that deliver value for money. The project nature encompasses all form of civil and building projects: school, hospital, road, rail, airport, dam etc. As such competitive open bidding system is preferred method to attract tenderers. The number of contractors that show interest in submitting tender document are both local and international contractors.

With the growing knowledge of sustainable development, the scope of sustainable infrastructure has now span beyond convectional cost-time-quality. Contractors are now evaluated based on economic, environmental, and social attributes. More importantly, there is an urgent need for employment creation through construction activities would significantly improve social well-being and promote conducive environment for project delivery.

Table A.1 summarises the criteria to be considered for selection and prejudiced views about the two categories of contractors.

Table A.1: Summary of the hypothetic attributes of the contractors

Features of local contractors

Matrix	Strength (Helpful)	Weakness (Harmful)
Local contractor	-Large population -Quantity of workers -Cheap labour	-Lack of funds -Deficiency in management level -Poor work ethic -Low level of internationalisation -Low level of computer integration -Poor working environment (health and safety) -Low level of modern construction methods

Features of local contractors

Matrix	Opportunity (Helpful)	Treats (Harmful)
Foreign contractor	-Financial strength -Technological endowment -Managerial skills	-Imposition of conditions on internal policy -Compromised workmanship -Interest is profit maximisation -Take the advantage of week governance -Neo-colonialism -Preference of own labour over local manpower -Lack of cultural integration

Guideline for deriving relative importance

Fundamental scale

Intensity of importance	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgement slightly favour one activity over another
5	Essential or strong importance	Experience and judgement strongly favour one activity over another
7	Very strong importance	An activity is favoured, and its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgements	When compromise in needed

The questionnaire for the prioritisation of element within and between clusters

Elements within Cluster: The question is phrased as follow:

- *Compare 'cooperation with workers' union' (E11) with 'employment creation for locals' (E12) according to their importance on their cluster (**Social Integration**)*

Prioritisation of Elements within Social Integration Cluster

Which has the greatest importance or influence?	☐ **E11**	☐ **E12**	☐ Equal Importance	
To what extent?	☐ Moderate	☐ Strong	☐ Very strong	☐ Extreme

.....where E11 = cooperation with workers' union, E12 = employment creation for locals (E12)

Elements within Clusters: The question is phrased as follow:

- *Compare 'employment creation for locals' (E12) with 'contractor social responsibility' (E13) in **social integration cluster** according to their importance on 'working and operating capital' (D10) in **project finance cluster***

Prioritisation of Elements between Clusters

Which has the greatest importance or influence?	☐ **E12**	☐ **E13**	☐ Equal Importance	
To what extent?	☐ Moderate	☐ strong	☐ Very strong	☐ Extreme

.....where E12 = employment creation for locals, and E13 = contractor social responsibility

Prioritisation of Clusters: The question is phrased as follow:

Compare the following clusters that have some influence upon the cluster 'Project Finance'

Prioritisation of Clusters

Which has the greatest importance or influence?	☐ **A**	☐ **B**	☐ Equal Importance	
To what extent?	☐ Moderate	☐ strong	☐ Very strong	☐ Extreme

.....where A = Environmental Conservation, and B = Reputation and integrity

Illustration of pairwise comparison matrix

Pairwise comparison						
	Cost	Quality	Time	Emplomt	Envion	H/Safety
	A	B	C	D	E	F
A	1	2	3	2	1	3
B	0.5	1	0.33	1	1	1
C	0.33	3	1	3	3	2
D	0.5	1	0.33	1	1	2
E	1	1	0.33	1	1	1
F	0.33	1	0.5	0.5	1	1

Relative importance of criteria within cluster

Selection criteria

Cluster	Criteria
Socio Integration	Cooperation with workers' union
	Employment creation for locals
	Contractor social responsibility initiatives
	Employee well-being
Asset	Quality of human resources
	Working capitals
	Availability of equipment
Management skills and innovation	Adequate training for operating process
	Proposed construction methods
	Experience in project of similar nature
	Project management experience
Reputation and integrity	Relationship with insurance companies
	Site safety records
	Claims and disputes history
Environmental Conservation	Environmental management certification
	Local material sourcing

Social Integration

	S1-Coop	S2-Empl	S3-CSR	S4-Welf
SI-Coop				
S2-Empl				
S3-CSR				
S4-Welf				

Asset

	TI-Qual	T2-Avail	T3-Capit
TI-Qual			
T2-Avail			
T3-Capit			

Management and Innovation

	K1-Train	K2-Const. M.	K3-Exp	K4-P Mgt
K1-Train				
K2-Const. M.				
K3-Exp				
K4-P Mgt				

Reputation and Integrity

	I1-Insu	I2-Site S.	I3-Claims
I1-Insu			
I2-Site S.			
I3-Claims			

Environment Conservation

	E1-W Mgt	E2-Local
E1-W Mgt		
E2-Local		

Relative importance of each criterion in reference to contractors

1 Cooperation with workers' union

	MCC	LLC
MCC	1	
LCC		1

2 Employment creation for locals

	MCC	LLC
MCC	1	
LCC		1

3 Contractor social responsibility initiatives

	MCC	LLC
MCC	1	
LCC		1

4 Employee well-being

	MCC	LLC
MCC	1	
LCC		1

5 Quality of human resources

	MCC	LLC
MCC	1	
LCC		1

6 Working capitals

	MCC	LLC
MCC	1	
LCC		1

7 Availability of equipment

	MCC	LLC
MCC	1	
LCC		1

8Adequate training for operating process

	MCC	LLC
MCC	1	
LCC		1

9 Proposed construction methods

	MCC	LLC
MCC	1	
LCC		1

10 Experience in project of similar nature

	MCC	LLC
MCC	1	
LCC		1

11 Project management experience

	MCC	LLC
MCC	1	
LCC		1

12 Relationship with insurance companies

	MCC	LLC
MCC	1	
LCC		1

13 Site safety records

	MCC	LLC
MCC	1	
LCC		1

14 Claims and disputes history

	MCC	LLC
MCC	1	
LCC		1

15Environmental management certification

	MCC	LLC
MCC	1	
LCC		1

16 Local material sourcing

	MCC	LLC
MCC	1	
LCC		1

Matrix of the impact of alternatives on the importance of criteria

MCC

	E1	E2	S1	S2	S3	S4	T1	T2	T3	K1	K2	K3	K4	I1	I2	I3
E1	1															
E2		1														
S1			1													
S2				1												
S3					1											
S4						1										
T1							1									
T2								1								
T3									1							
K1										1						
K2											1					
K3												1				
K4													1			
I1														1		
I2															1	
I3																1

where E1 = Waste management, E2 = Local material sourcing, L1= Relationship with insurance companies, L2= Site safety records, L3= Claims and disputes history, K1= Adequate training for operating process, K2= Proposed construction methods, K3= Experience in project of similar nature, K4= Project management experience, S1= Cooperation with workers' union, S2= Employment creation for locals, S3= Contractor social responsibility initiatives, S4= Employee welfare, T1= Quality of human resources, T2= Availability of equipment, T3= Working capital

LCC

	E1	E2	S1	S2	S3	S4	T1	T2	T3	K1	K2	K3	K4	I1	I2	I3
E1	1															
E2		1														
S1			1													
S2				1												
S3					1											
S4						1										
T1							1									
T2								1								
T3									1							
K1										1						
K2											1					
K3												1				
K4													1			
I1														1		
I2															1	
I3																1

where E1 = Waste management, E2 = Local material sourcing, L1= Relationship with insurance companies, L2= Site safety records, L3= Claims and disputes history, K1= Adequate training for operating process, K2= Proposed construction methods, K3= Experience in project of similar nature, K4= Project management experience, S1= Cooperation with workers' union, S2= Employment creation for locals, S3= Contractor social responsibility initiatives, S4= Employee welfare, T1= Quality of human resources, T2= Availability of equipment, T3= Working capital

Matrix of the cluster priority with respect to the goal

	1-Social integration	2-Asset	3-Mgt & Inn	4-Rep & Int	Environ.
1-Social integration					
2-Asset					
3-Mgt & Inno					
4-Rep & Int					
./,./4-Environ					

Appendix 4: Validation Questionnaire Survey

Dear Sir,

A QUESTIONNAIRE FOR VALIDATING MODEL FOR PRE-EVALUATION OF CONTRACTORS FOR PPP INFRASTRUCTURE PROJECTS IN NIGERIA

The aim of this questionnaire is to gather and assess experts' opinions on the attached model, which is intended for assisting MDAs and related government bodies that engage in PPP in evaluating contractors for infrastructure projects. This is meant for validating the proposed sustainable infrastructure delivery (SID) model and the critical selection criteria as to its significant to construction industry, workability in practice and adequacy in addressing the decision problem confronting MDAs on selecting contractors that deliver sustainable infrastructure.

The questionnaire is developed to 3 sections. Section 1 gathers your background information. Section 2 and 3 ask for your opinions or comments on the structure of the SID model and pre-evaluation criteria respectively.

Please note that there are no correct or incorrect responses, only your much-needed opinion. Please return the completed questionnaire in a word document format for easy data mining.

I would like to thank you in advance for your valued and kind consideration. If you would like any further information about the research, please let me know

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Section 1 Background of Respondent

Name of Respondents (optional)	
Profession	
Qualification	
Current job designation	
Years of experience in the construction industry	

Section 2: General Impression on the SID model

1. Does the model address important issues in contractors' evaluation process for SID
Yes, quite significant
Yes, but not significant
No, would make no difference
Not sure of its significance
Comment (if any)
2. Would you say that that the model is capable of predicting contractors that would deliver sustainable infrastructure?
Yes, highly capable
Yes, capable
No, not capable
Not sure of its capability
Comment (if any)
3. Would you say that the model is simple, clear, and easy to understand use with little or no practical difficulties?
Yes
No
4. if No to Q3, please comment on the specific aspects of the model that, in your view, is likely to cause major difficulties to its use?
5. What is your opinion on the description of the model and its lay out?
Comprehensive
Adequate
Poor
Comment (if any)
6. In your opinion, are ther any further matters of importance which ought to be included in the model or considered?
Yes
No
7. If yes to Q6, please specify:

Section 3: Impression on Pre-Evaluation Criteria

8. What is your opinion on the approaches/methods used to deduce criteria for pre-evaluation of contractors?
Very suitable
Suitable
Not suitable
Not sure of its suitability
Comments (if any)

9. What is your opinion on the set of criteria used in evaluating and ranking sustainability of contractors?
Very suitable
Suitable
Not suitable
Not sure of its suitability
Comments (if any)

10. What is your opinion on the the scale of "1 - 5" adopted for pairwise comparison of the selection criteria and ranking of contractors?
Very suitable
Suitable
Not suitable
Not sure of its suitability
Comments (if any)

11. In your opinion, are there any other important criteria that were not considered?
Yes
No

12, If you have answered Yes to Q11, please list these criteria that ought to be considered

13. Please provide any other general comments that you have on the model or suggestions for improvement (continue on a seperate sheet if necessary)

Thank you very much for your time

NB: Confidentiality and anonymity are guaranteed. All information collected will conform to the University of Derby Ethical procedure

Appendix 5: Exemplar Normalised Matrix and Consistency Ratio Computation

a) Normalised matrix is obtained by dividing the elements of each column of the matrix by the sum of that column (Table a).

Table a: Examplar Normalised matrix

Pairwise comparison										
	Cost	Quality	Time	Emplomt	Envion	H/Safety				
	A	B	C	D	E	F				
A	1	2	3	2	1	3				
B	0.5	1	0.33	1	1	1				
C	0.33	3	1	3	3	2				
D	0.5	1	0.33	1	1	2				
E	1	1	0.33	1	1	1				
F	0.33	1	0.5	0.5	1	1				
Sum	3.66	9	5.49	8.5	8	10				
Standadised matrix or normalised value										
	A	B	C	D	E	F	Weight		Sum	eVector
A	0.27	0.22	0.55	0.24	0.13	0.30	28.37%		1.70	0.283698
B	0.14	0.11	0.06	0.12	0.13	0.10	10.84%		0.65	0.108413
C	0.09	0.33	0.18	0.35	0.38	0.20	25.56%		1.53	0.255598
D	0.14	0.11	0.06	0.12	0.13	0.20	12.51%		0.75	0.12508
E	0.27	0.11	0.06	0.12	0.13	0.10	13.12%		0.79	0.131182
F	0.09	0.11	0.09	0.06	0.13	0.10	9.60%		0.58	0.096029
Sum Columns	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1

In pairwise comparison matrix in Table a (using Super Decisions), the current judgement is shown in the diagonal right-hand side of the screen. For n comparison elements, there are *n(n-1) /2* judgements. The software computes the reciprocal of the judgements for the lower left-hand side of the scree.

To obtain priority vector, also known as Eigen vector (e Vector), elements in each resulting row are added (resulting in a row sum), and the sum is divided by the number of elements in the row (Cheng and Li, 2004). For example, vector for 'A' is 0.283698 (1.70/6) (i.e. sum of row values divided by number variables on a row. Sum of priority vector should be '1' when normalised.

b) Consistency ratio…… $C.R.(A) = \frac{C.I.(A)}{R.I.}$,

…. where CR = Consistency Ratio, CI = Consistency Index, RI = Random Consistency Index

To compute a CI of matrix A:

……. $CI = \frac{\lambda_{max} - n}{n - 1}$,

….where [λmax] = Principal Eigen vector, n = number of criteria

Principal Eigen vector [λmax] is the total value obtained from the the product of eVector in normalised matrix with the corresponding 'sum' in comparison matrix. Using Table 4.6 as an illustration, λmax = 3.66 (0.2837) + 9 (0.1084) + 5.49 (0.2556) + 8.5 (0.1251) + 8 (0.1312) + 10(0.0960) = 6.4901

…..λ (Principal Eigen value = 6.4901

…n (number of criteria) = 6 (see Table 5.9)

CI…$= \frac{6.4901 - 6}{6 - 1} = \frac{0.4901}{5} = 0.0980$
……

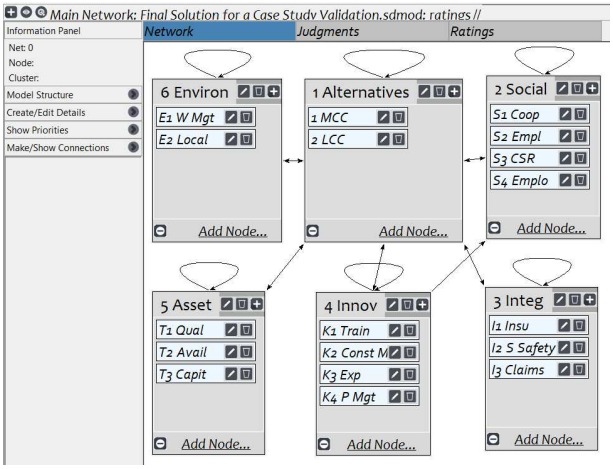
CI = 0.0980

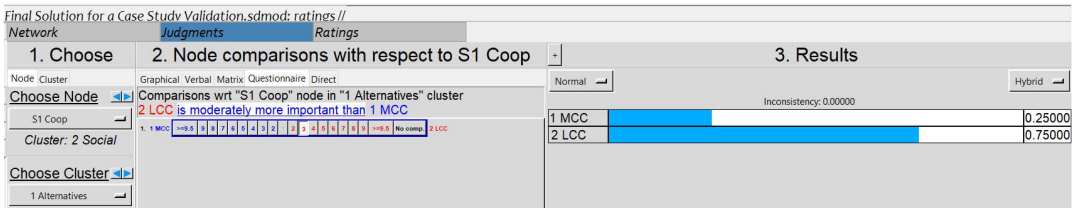
The correspondent RI for 6 criteria = 1.24

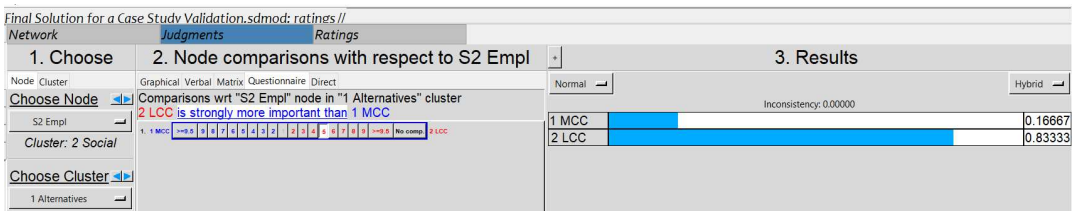
Therefore, $C.R.(A) = \frac{C.I.(A)}{R.I.}$, = 0.0980/1.24 = 0.0790

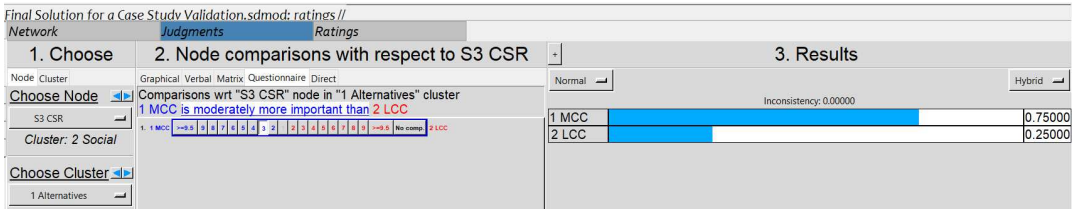
The above result infers that the judgement is consistent since degree of inconsistent is within 10% threshold allowed for above 4 by 4 matrixes (Saaty, 2013).

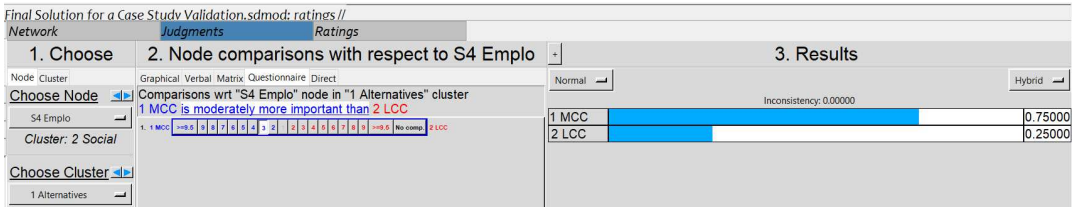
Appendix 6: Model Validation Results

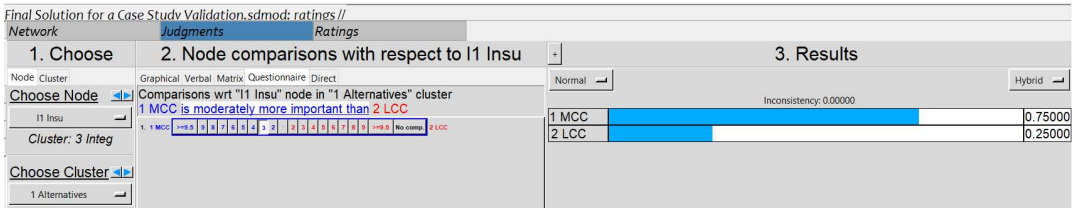


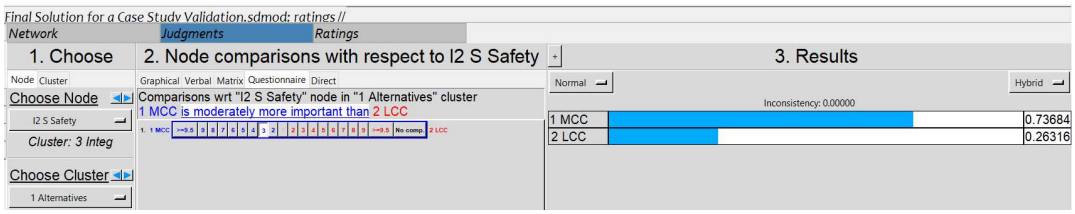


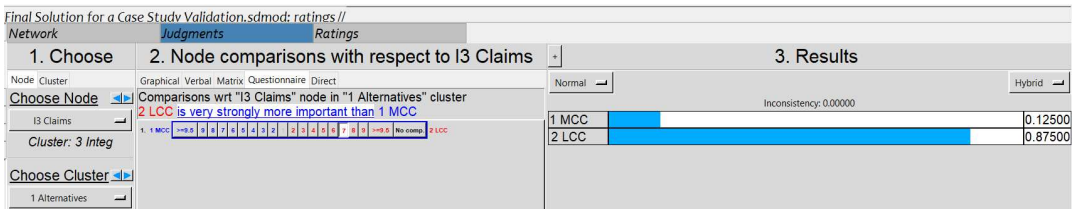


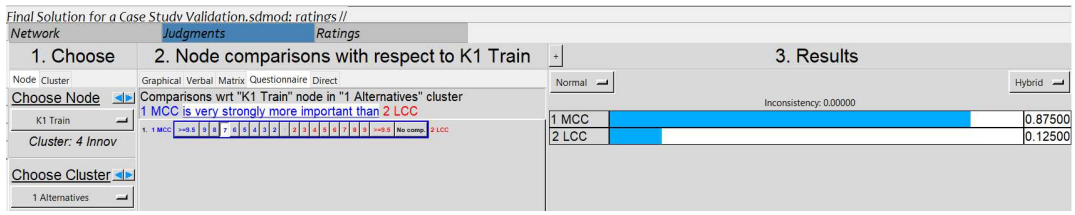


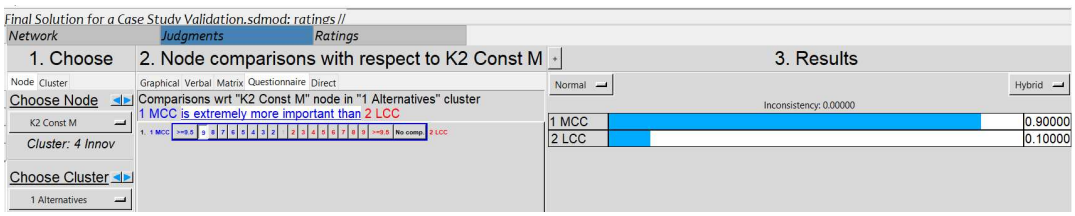


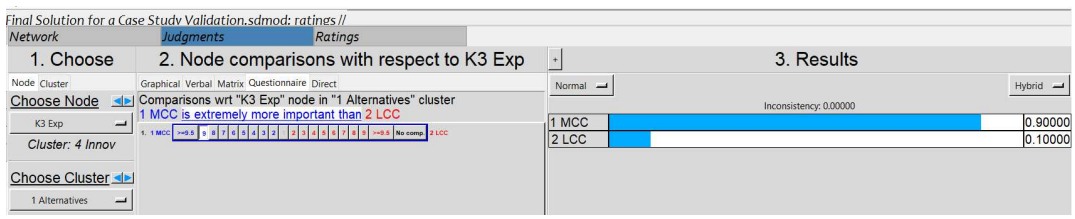

Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to I1 Insu
3. Results
Node Cluster
Choose Node
I1 Insu
Cluster: 3 Integ
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "I1 Insu" node in "1 Alternatives" cluster
1 MCC is moderately more important than 2 LCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.75000
2 LCC 0.25000

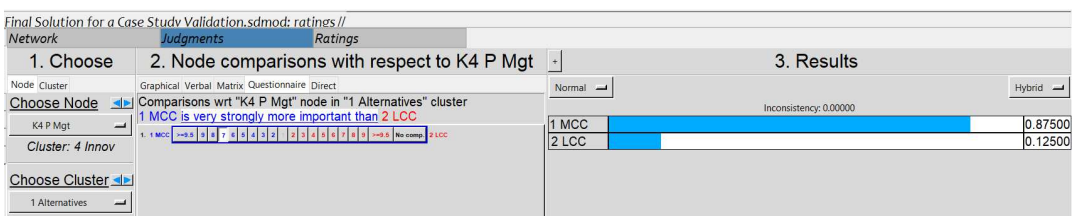

Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to I2 S Safety
3. Results
Node Cluster
Choose Node
I2 S Safety
Cluster: 3 Integ
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "I2 S Safety" node in "1 Alternatives" cluster
1 MCC is moderately more important than 2 LCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.73684
2 LCC 0.26316

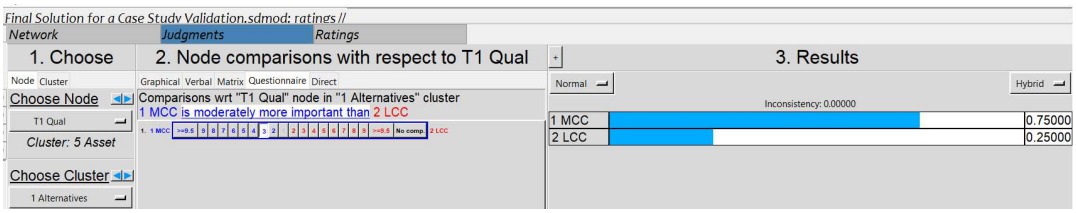

Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to I3 Claims
3. Results
Node Cluster
Choose Node
I3 Claims
Cluster: 3 Integ
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "I3 Claims" node in "1 Alternatives" cluster
2 LCC is very strongly more important than 1 MCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.12500
2 LCC 0.87500

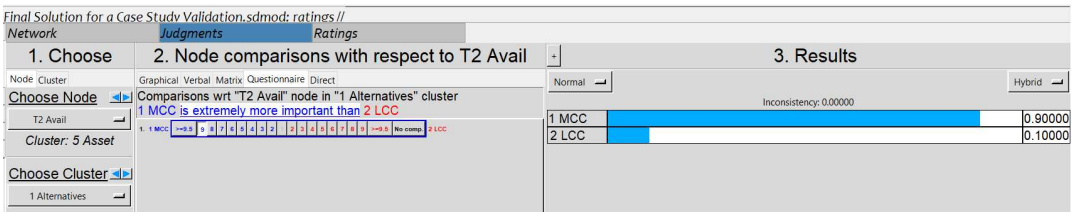

Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to K1 Train
3. Results
Node Cluster
Choose Node
K1 Train
Cluster: 4 Innov
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "K1 Train" node in "1 Alternatives" cluster
1 MCC is very strongly more important than 2 LCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.87500
2 LCC 0.12500

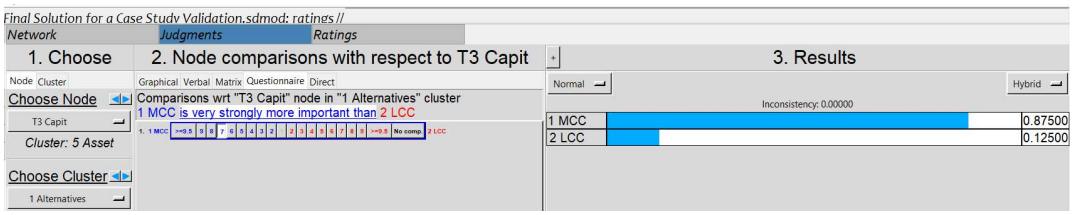

Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to K2 Const M
3. Results
Node Cluster
Choose Node
K2 Const M
Cluster: 4 Innov
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "K2 Const M" node in "1 Alternatives" cluster
1 MCC is extremely more important than 2 LCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.90000
2 LCC 0.10000

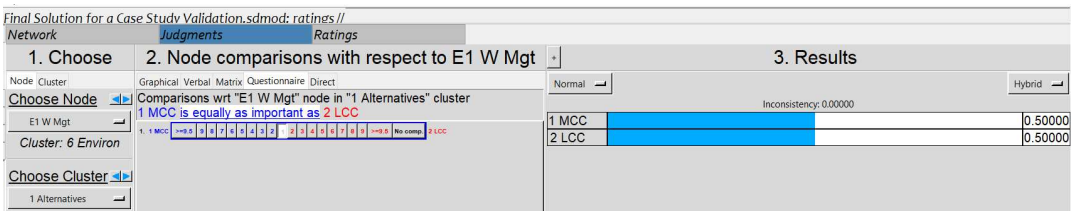

Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to K3 Exp
3. Results
Node Cluster
Choose Node
K3 Exp
Cluster: 4 Innov
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "K3 Exp" node in "1 Alternatives" cluster
1 MCC is extremely more important than 2 LCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.90000
2 LCC 0.10000

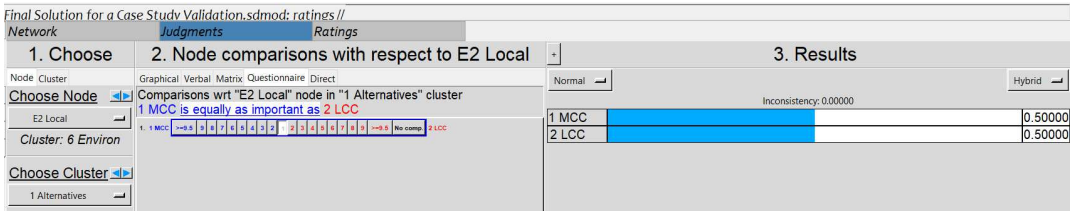

Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to K4 P Mgt
3. Results
Node Cluster
Choose Node
K4 P Mgt
Cluster: 4 Innov
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "K4 P Mgt" node in "1 Alternatives" cluster
1 MCC is very strongly more important than 2 LCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.87500
2 LCC 0.12500


Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to T1 Qual
3. Results
Node Cluster
Choose Node
T1 Qual
Cluster: 5 Asset
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "T1 Qual" node in "1 Alternatives" cluster
1 MCC is moderately more important than 2 LCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.75000
2 LCC 0.25000


Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to T2 Avail
3. Results
Node Cluster
Choose Node
T2 Avail
Cluster: 5 Asset
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "T2 Avail" node in "1 Alternatives" cluster
1 MCC is extremely more important than 2 LCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.90000
2 LCC 0.10000


Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to T3 Capit
3. Results
Node Cluster
Choose Node
T3 Capit
Cluster: 5 Asset
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "T3 Capit" node in "1 Alternatives" cluster
1 MCC is very strongly more important than 2 LCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.87500
2 LCC 0.12500


Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to E1 W Mgt
3. Results
Node Cluster
Choose Node
E1 W Mgt
Cluster: 6 Environ
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "E1 W Mgt" node in "1 Alternatives" cluster
1 MCC is equally as important as 2 LCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.50000
2 LCC 0.50000


Final Solution for a Case Study Validation.sdmod: ratings //
Network
Judgments
Ratings
1. Choose
2. Node comparisons with respect to E2 Local
3. Results
Node Cluster
Choose Node
E2 Local
Cluster: 6 Environ
Choose Cluster
1 Alternatives
Graphical Verbal Matrix Questionnaire Direct
Comparisons wrt "E2 Local" node in "1 Alternatives" cluster
1 MCC is equally as important as 2 LCC
Normal
Hybrid
Inconsistency: 0.00000
1 MCC 0.50000
2 LCC 0.50000

Main Network: Final Solution for a Case Study Validation.sdmod: ratings: Unweighted Super Matrix

Clusters	Nodes	1 MCC	2 LCC	S1 Coop	S2 Empl	S3 CSR	S4 Emplo	I1 Insu	I2 S Safety	I3 Claims	K1 Train	K2 Const M	K3 Exp	K4 P Mgt	T1 Qual	T2 Avail	T3 Capit	E1 W Mgt	E2 Local
1 Alternatives	1 MCC	0.000000	1.000000	0.250000	0.166667	0.750000	0.750000	0.750000	0.736842	0.125000	0.875000	0.900000	0.900000	0.875000	0.750000	0.900000	0.875000	0.500000	0.500000
	2 LCC	1.000000	0.000000	0.750000	0.833333	0.250000	0.250000	0.250000	0.263158	0.875000	0.125000	0.100000	0.100000	0.125000	0.250000	0.100000	0.125000	0.500000	0.500000
2 Social	S1 Coop	0.116264	0.108647	0.000000	0.261800	0.285670	0.231702	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S2 Empl	0.325745	0.645961	0.356921	0.000000	0.341064	0.575014	0.000000	0.000000	0.000000	0.833333	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S3 CSR	0.056397	0.074999	0.066255	0.115588	0.000000	0.193284	0.000000	0.000000	0.000000	0.166667	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S4 Emplo	0.501594	0.170393	0.576824	0.622611	0.373266	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3 Integ	I1 Insu	0.249563	0.207904	0.000000	0.000000	0.000000	0.000000	0.000000	0.756098	0.500000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	I2 S Safety	0.661518	0.065599	0.000000	0.000000	0.000000	0.000000	0.761905	0.000000	0.500000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	I3 Claims	0.088919	0.726498	0.000000	0.000000	0.000000	0.000000	0.238095	0.243902	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4 Innov	K1 Train	0.117036	0.070514	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.241515	0.324521	0.253963	0.000000	0.000000	0.000000	0.000000	0.000000
	K2 Const M	0.355883	0.158337	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.360429	0.000000	0.532177	0.307117	0.000000	0.000000	0.000000	0.000000	0.000000
	K3 Exp	0.456405	0.126432	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.389293	0.559432	0.000000	0.438920	0.000000	0.000000	0.000000	0.000000	0.000000
	K4 P Mgt	0.070676	0.644716	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.250279	0.199053	0.143302	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5 Asset	T1 Qual	0.099910	0.177630	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.322580	0.500000	0.000000	0.000000
	T2 Avail	0.238565	0.127062	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.163934	0.000000	0.500000	0.000000	0.000000
	T3 Capit	0.661524	0.695308	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.836066	0.677420	0.000000	0.000000	0.000000
6 Environ	E1 W Mgt	0.583333	0.322580	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	1.000000
	E2 Local	0.416667	0.677420	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000

Done

Main Network: Final Solution for a Case Study Validation.sdmod: ratings: Weighted Super Matrix

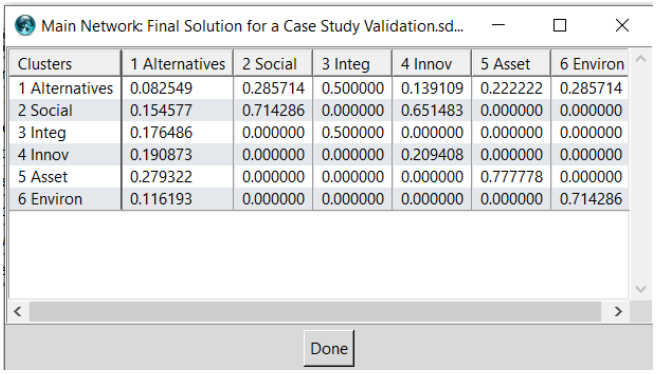
Clusters	Nodes	1 MCC	2 LCC	S1 Coop	S2 Empl	S3 CSR	S4 Emplo	I1 Insu	I2 S Safety	I3 Claims	K1 Train	K2 Const M	K3 Exp	K4 P Mgt	T1 Qual	T2 Avail	T3 Capit	E1 W Mgt	E2 Local
1 Alternatives	1 MCC	0.000000	0.082549	0.071429	0.047619	0.214286	0.214286	0.375000	0.368421	0.062500	0.121720	0.359230	0.359230	0.349252	0.166667	0.200000	0.194444	0.142857	0.142857
	2 LCC	0.082549	0.000000	0.214286	0.238095	0.071429	0.071429	0.125000	0.131579	0.437500	0.017389	0.039914	0.039914	0.049893	0.055556	0.022222	0.027778	0.142857	0.142857
2 Social	S1 Coop	0.017972	0.016794	0.000000	0.187000	0.204050	0.165502	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S2 Empl	0.050353	0.099851	0.254943	0.000000	0.243617	0.410725	0.000000	0.000000	0.000000	0.542903	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S3 CSR	0.008718	0.011593	0.047325	0.082563	0.000000	0.138060	0.000000	0.000000	0.000000	0.108581	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	S4 Emplo	0.077535	0.026339	0.412017	0.444722	0.266618	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3 Integ	I1 Insu	0.044045	0.036692	0.000000	0.000000	0.000000	0.000000	0.000000	0.378049	0.250000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	I2 S Safety	0.116749	0.011577	0.000000	0.000000	0.000000	0.000000	0.380952	0.000000	0.250000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	I3 Claims	0.015693	0.128217	0.000000	0.000000	0.000000	0.000000	0.119048	0.121951	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4 Innov	K1 Train	0.022339	0.013459	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.145116	0.194990	0.152595	0.000000	0.000000	0.000000	0.000000	0.000000
	K2 Const M	0.067929	0.030222	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.075477	0.000000	0.319761	0.184533	0.000000	0.000000	0.000000	0.000000	0.000000
	K3 Exp	0.087115	0.024133	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.081521	0.336138	0.000000	0.263728	0.000000	0.000000	0.000000	0.000000	0.000000
	K4 P Mgt	0.013490	0.123059	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.052410	0.119602	0.086104	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5 Asset	T1 Qual	0.027907	0.049616	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.250896	0.388889	0.000000	0.000000
	T2 Avail	0.066637	0.035491	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.127504	0.000000	0.388889	0.000000	0.000000
	T3 Capit	0.184778	0.194214	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.650274	0.526882	0.000000	0.000000	0.000000
6 Environ	E1 W Mgt	0.067779	0.037482	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.714286
	E2 Local	0.048414	0.078711	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.714286	0.000000

Done

Main Network: Final Solution for a Case Study Validation.sdmod: ratings: Limit Matrix

Clusters	Nodes	1 MCC	2 LCC	S1 Coop	S2 Empl	S3 CSR	S4 Emplo	I1 Insu	I2 S Safety	I3 Claims	K1 Train	K2 Const M	K3 Exp	K4 P Mgt	T1 Qual	T2 Avail	T3 Capit	E1 W Mgt	E2 Local
1 Alternatives	1 MCC	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393	0.156393
	2 LCC	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592	0.085592
2 Social	S1 Coop	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862	0.029862
	S2 Empl	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065	0.063065
	S3 CSR	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193	0.019193
	S4 Emplo	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848	0.059848
3 Integ	I1 Insu	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742	0.028742
	I2 S Safety	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494	0.035494
	I3 Claims	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179	0.021179
4 Innov	K1 Train	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003	0.018003
	K2 Const M	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415	0.028415
	K3 Exp	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913	0.031913
	K4 P Mgt	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732	0.019732
5 Asset	T1 Qual	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502	0.083502
	T2 Avail	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141	0.079141
	T3 Capit	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518	0.141518
6 Environ	E1 W Mgt	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059	0.049059
	E2 Local	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350	0.049350

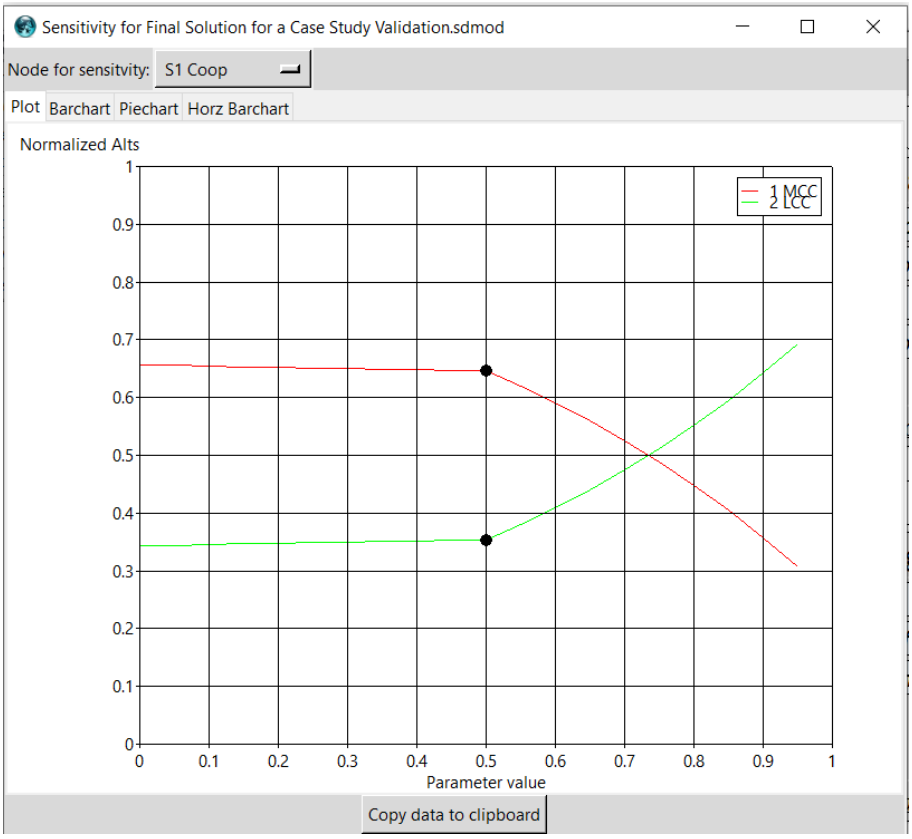
Done



Clusters	1 Alternatives	2 Social	3 Integ	4 Innov	5 Asset	6 Environ
1 Alternatives	0.082549	0.285714	0.500000	0.139109	0.222222	0.285714
2 Social	0.154577	0.714286	0.000000	0.651483	0.000000	0.000000
3 Integ	0.176486	0.000000	0.500000	0.000000	0.000000	0.000000
4 Innov	0.190873	0.000000	0.000000	0.209408	0.000000	0.000000
5 Asset	0.279322	0.000000	0.000000	0.000000	0.777778	0.000000
6 Environ	0.116193	0.000000	0.000000	0.000000	0.000000	0.714286

Icon	Name	Normalized by Cluster	Limiting
No Icon	1 MCC	0.64629	0.156393
No Icon	2 LCC	0.35371	0.085592
No Icon	S1 Coop	0.17365	0.029862
No Icon	S2 Empl	0.36673	0.063065
No Icon	S3 CSR	0.11161	0.019193
No Icon	S4 Emplo	0.34802	0.059848
No Icon	I1 Insu	0.33650	0.028742
No Icon	I2 S Safety	0.41555	0.035494
No Icon	I3 Claims	0.24795	0.021179
No Icon	K1 Train	0.18359	0.018003
No Icon	K2 Const M	0.28976	0.028415
No Icon	K3 Exp	0.32543	0.031913
No Icon	K4 P Mgt	0.20122	0.019732
No Icon	T1 Qual	0.27453	0.083502
No Icon	T2 Avail	0.26019	0.079141
No Icon	T3 Capit	0.46527	0.141518
No Icon	E1 W Mgt	0.49852	0.049059
No Icon	E2 Local	0.50148	0.049350

The priorities from the Limit Supermatrix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Node for sensitvity: S1 Coop
Plot Barchart Piechart Horz Barchart
Normalized Alts
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2 LCC
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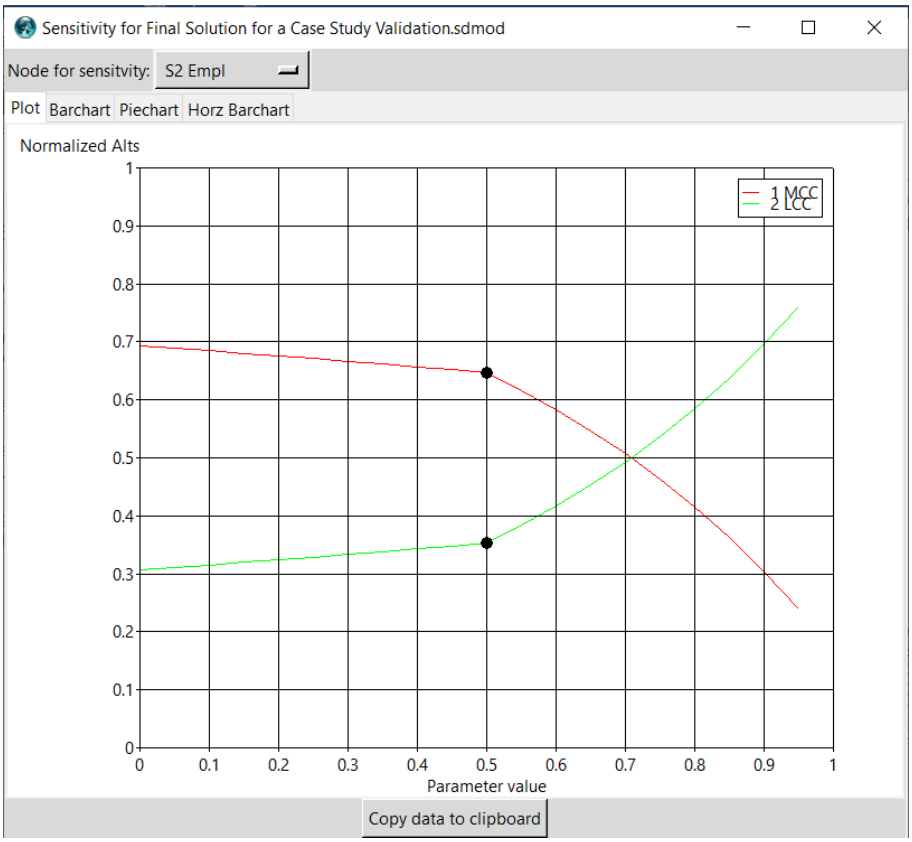
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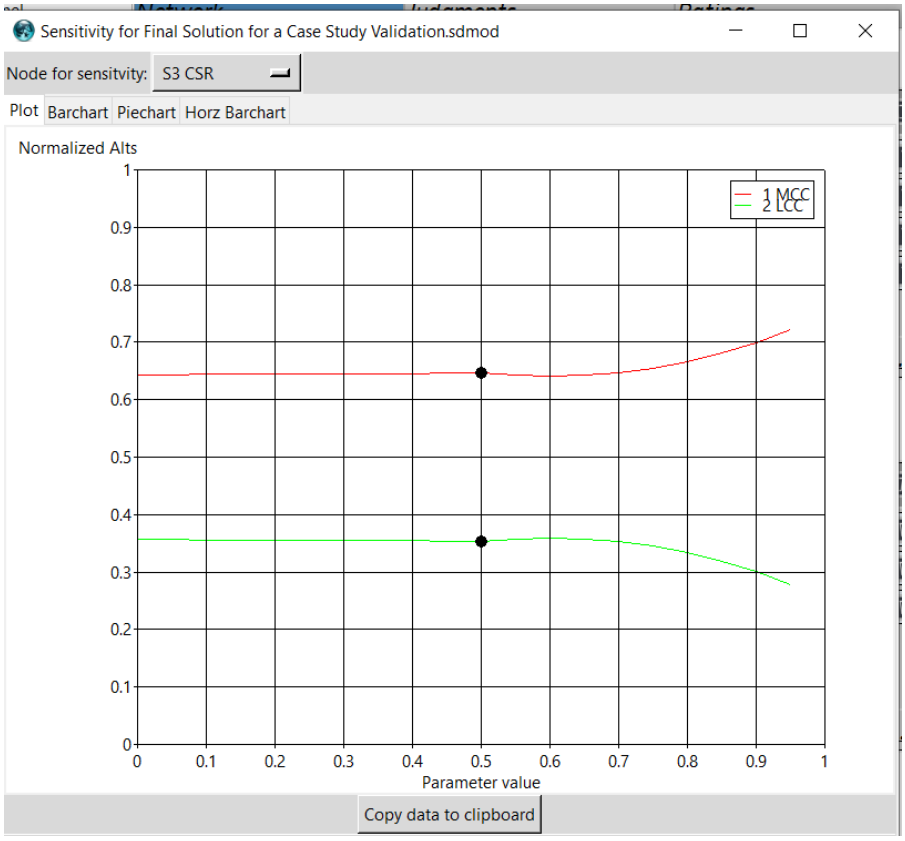
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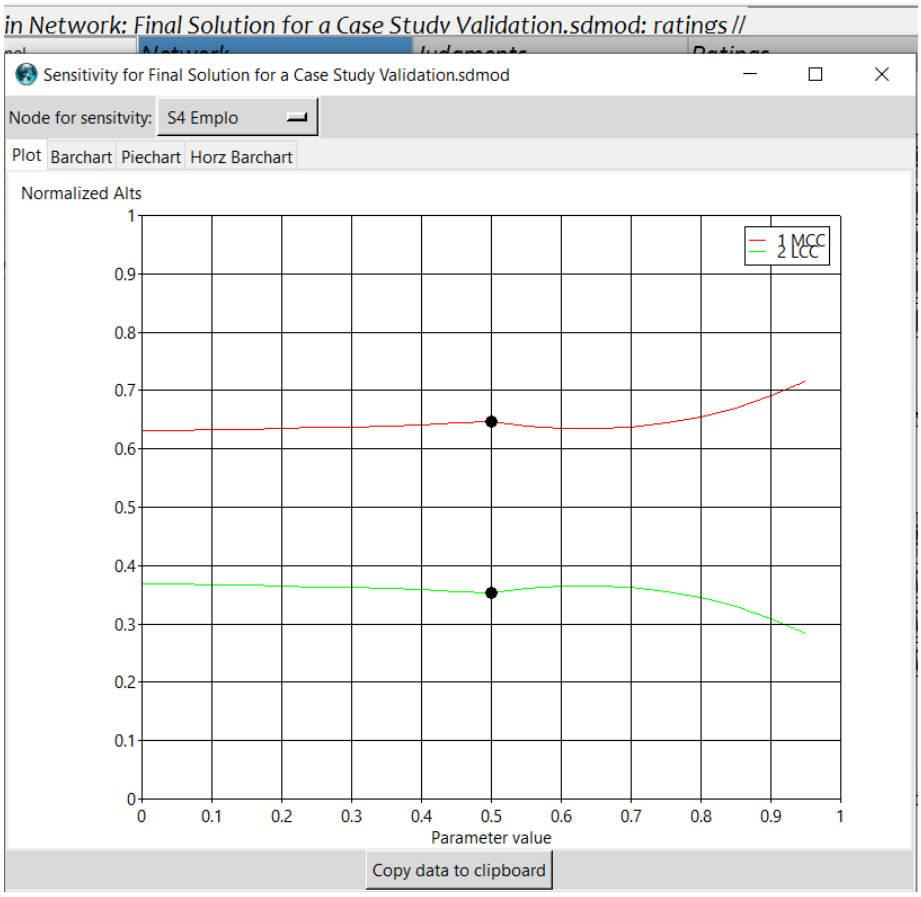
in Network: Final Solution for a Case Study Validation.sdmod: ratings //
Sensitivity for Final Solution for a Case Study Validation.sdmod
Node for sensitvity: S4 Emplo
Plot Barchart Piechart Horz Barchart
Normalized Alts
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2 LCC
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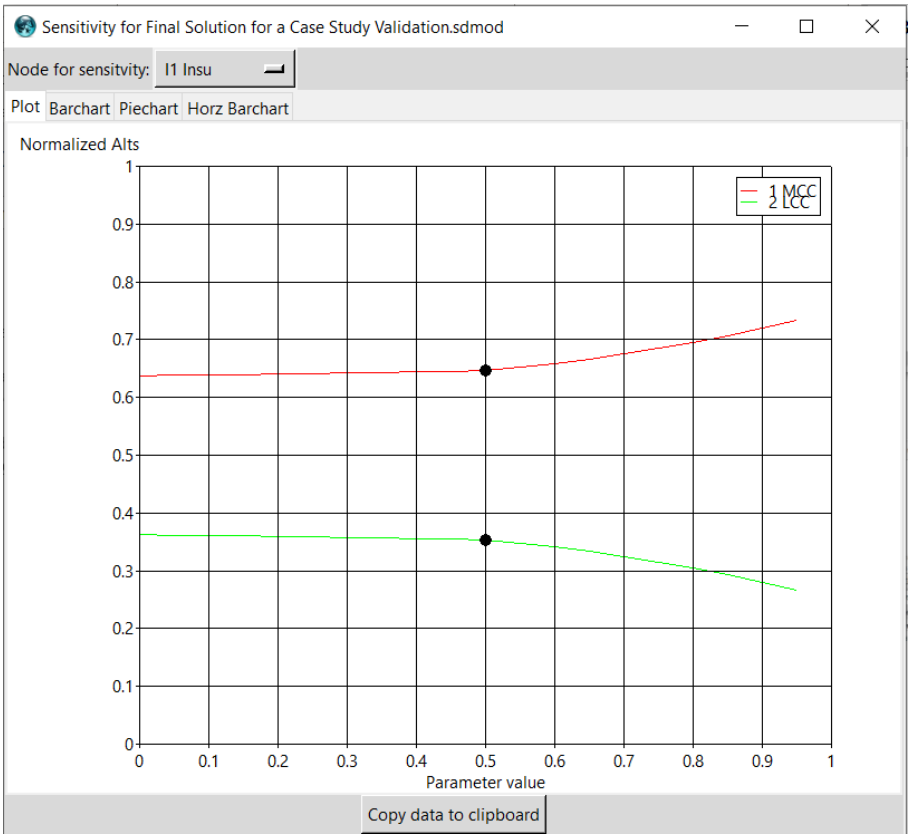
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Node for sensitvity:
I1 Insu
Plot
Barchart
Piechart
Horz Barchart
Normalized Alts
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2 LCC
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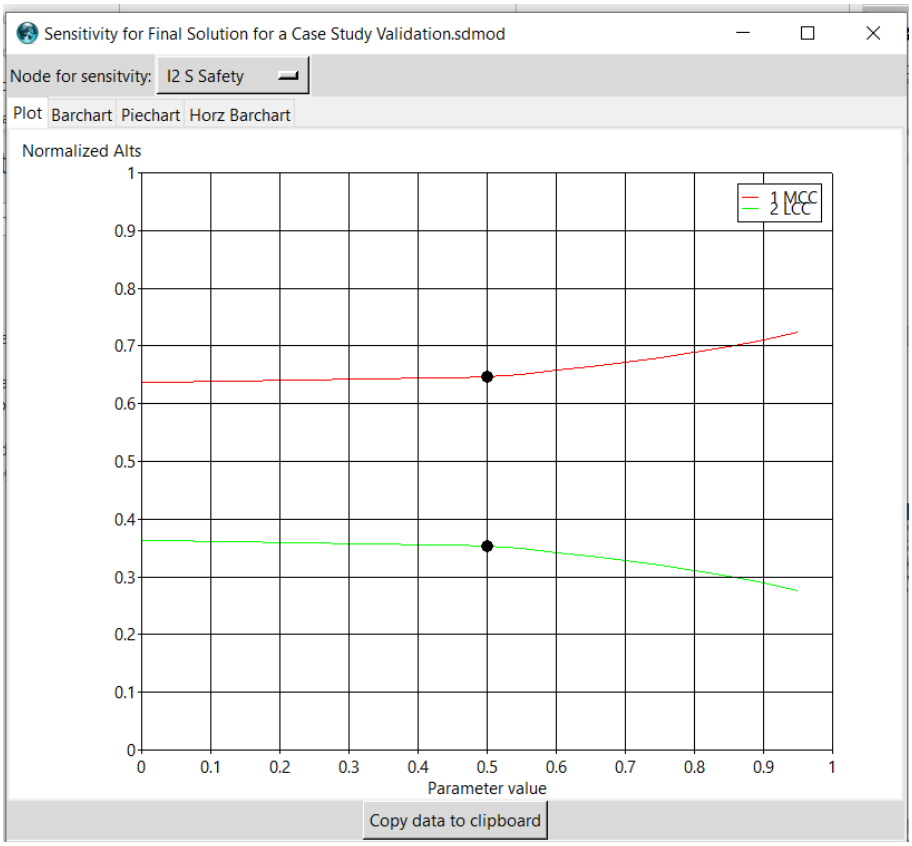
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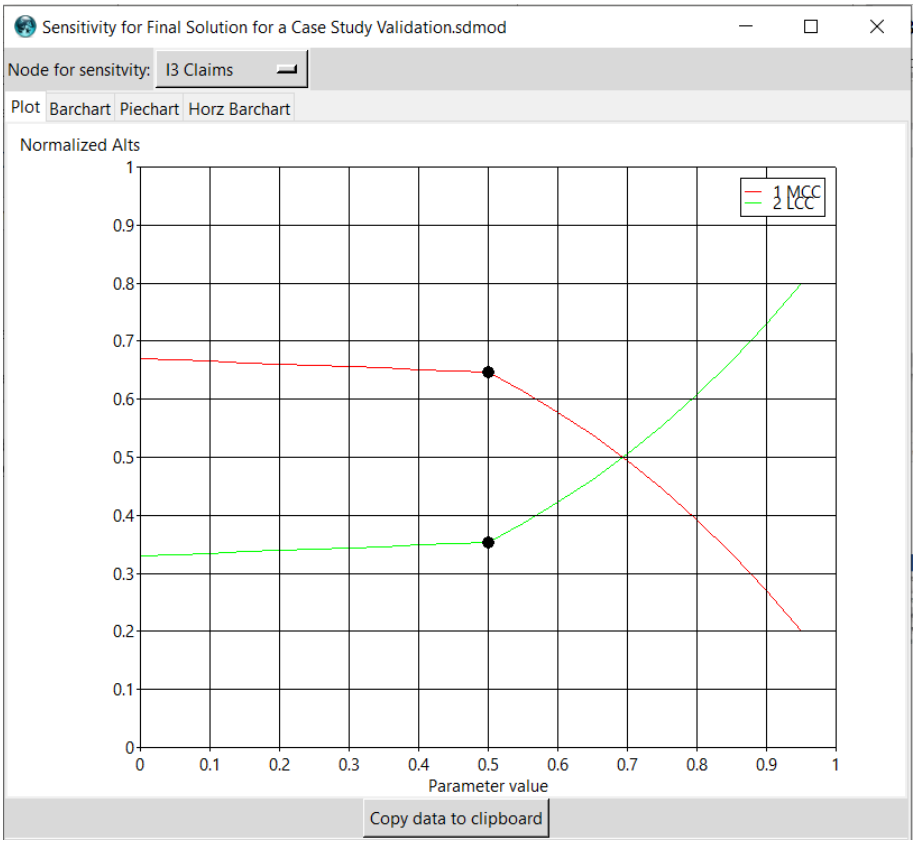
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Barchart
Piechart
Horz Barchart
Normalized Alts
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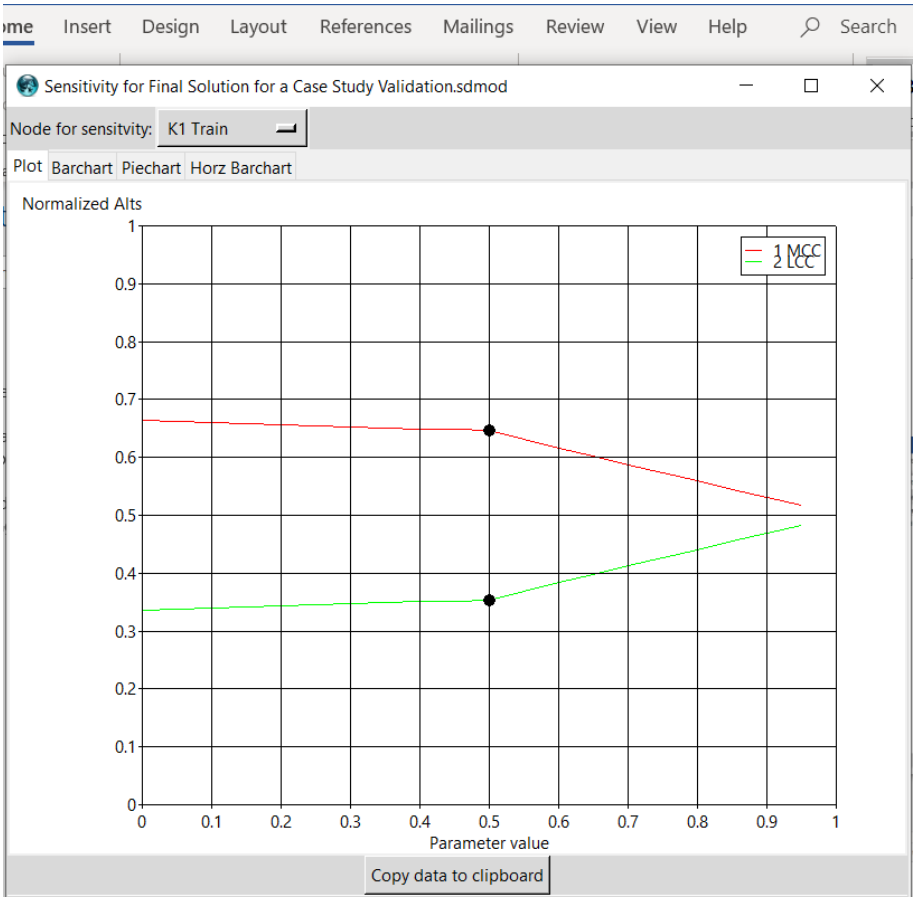
2 LCC
Parameter value
Copy data to clipboard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Sensitivity for Final Solution for a Case Study Validation.sdmod
Node for sensitvity: K1 Train
Plot
Barchart
Piechart
Horz Barchart
Normalized Alts
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2 LCC
Parameter value
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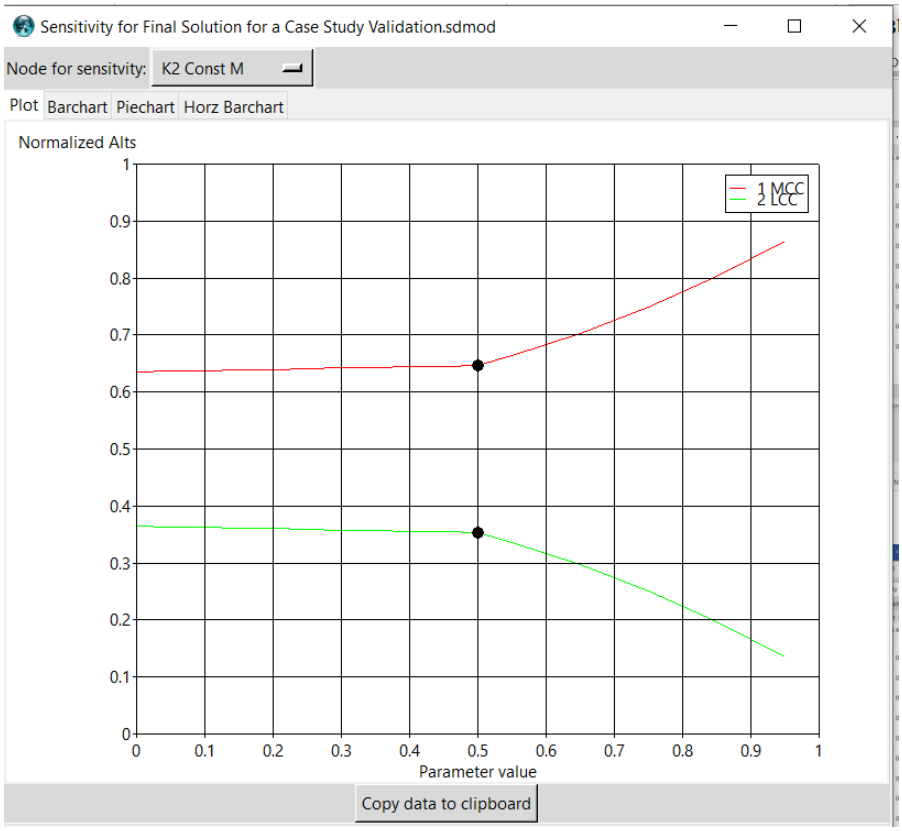
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Barchart
Piechart
Horz Barchart
Normalized Alts
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2 LCC
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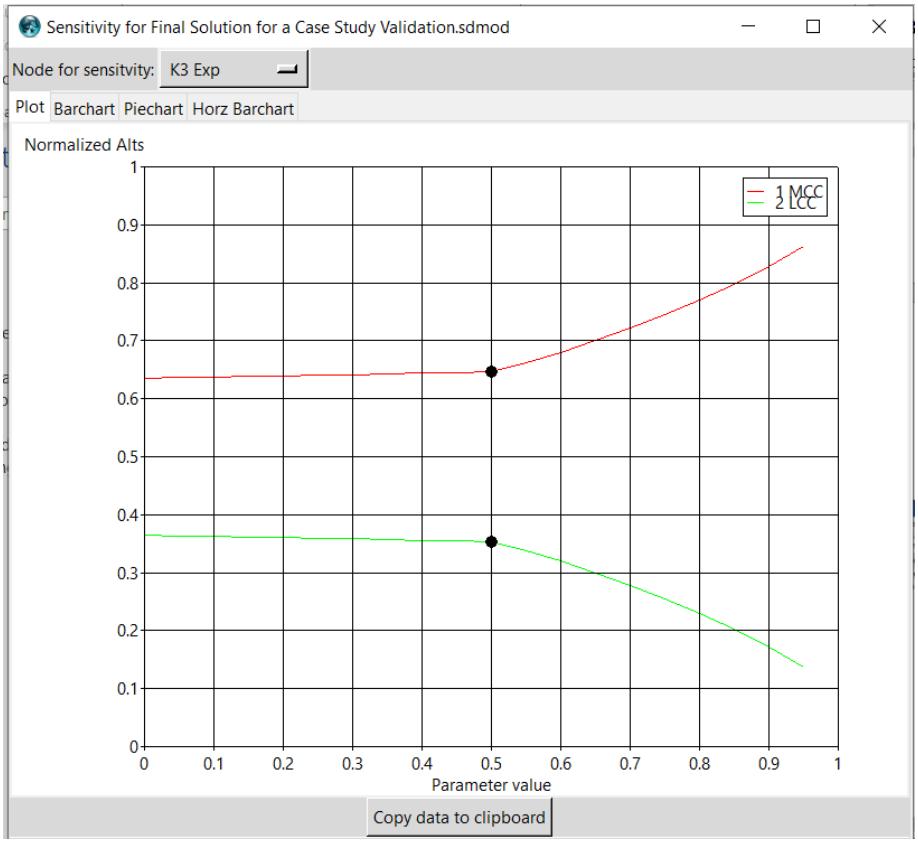
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Barchart
Piechart
Horz Barchart
Normalized Alts
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2 LCC
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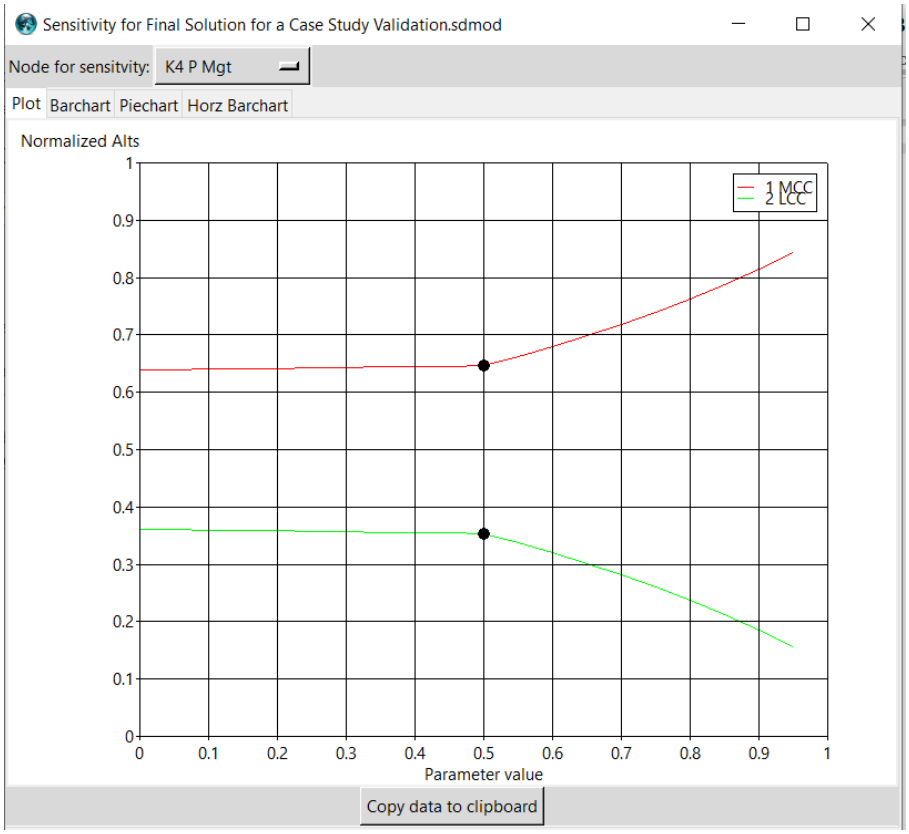
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K4 P Mgt
Plot
Barchart
Piechart
Horz Barchart
Normalized Alts
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2 LCC
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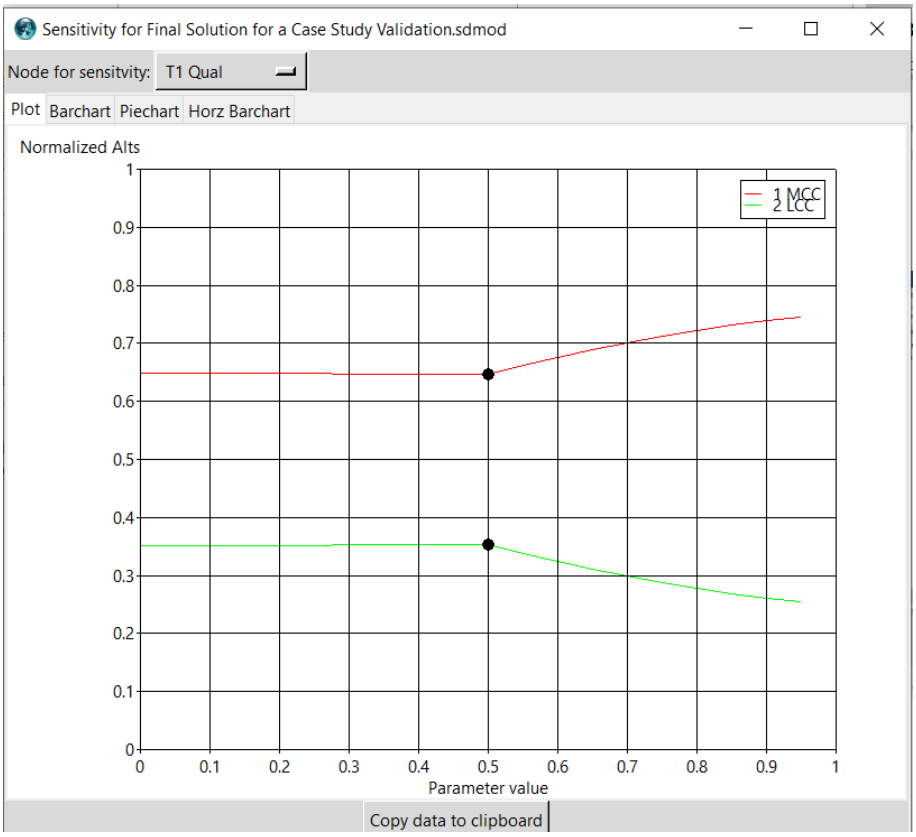
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T1 Qual
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Barchart
Piechart
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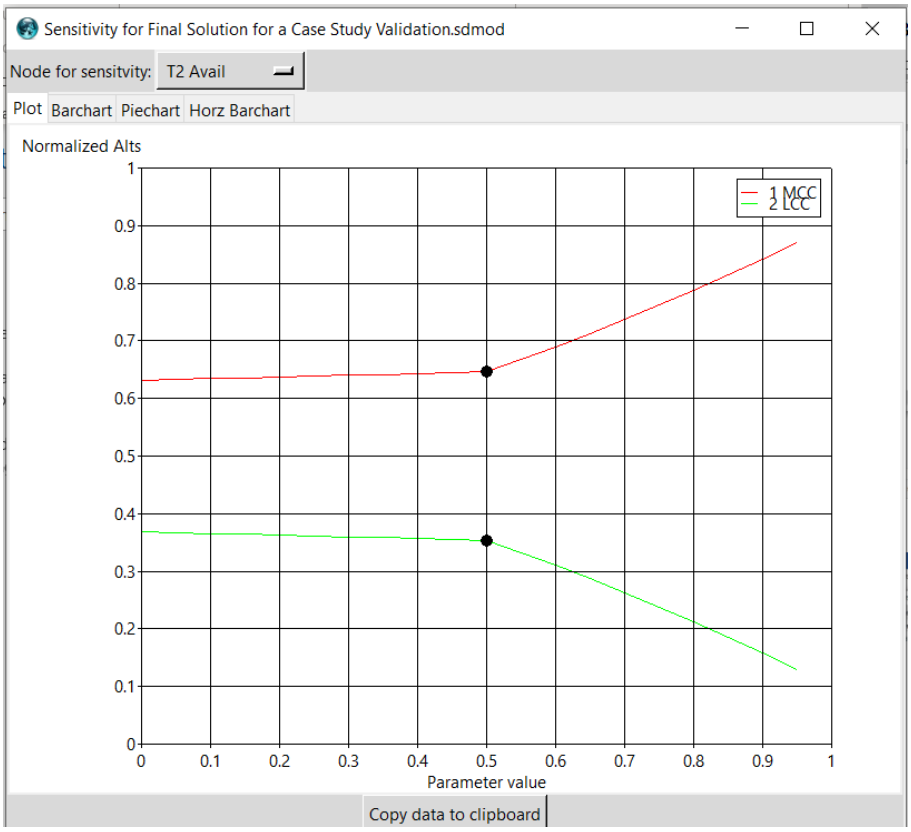
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Node for sensitvity: T2 Avail
Plot Barchart Piechart Horz Barchart
Normalized Alts
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2 LCC
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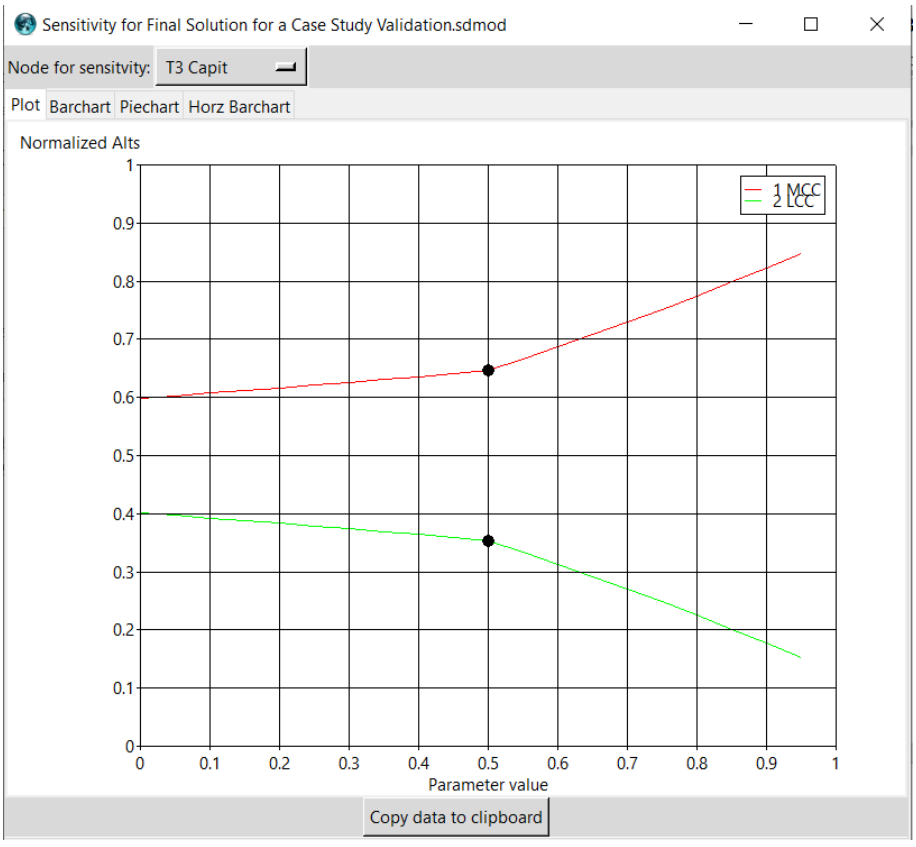
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Node for sensitvity: T3 Capit
Plot Barchart Piechart Horz Barchart
Normalized Alts
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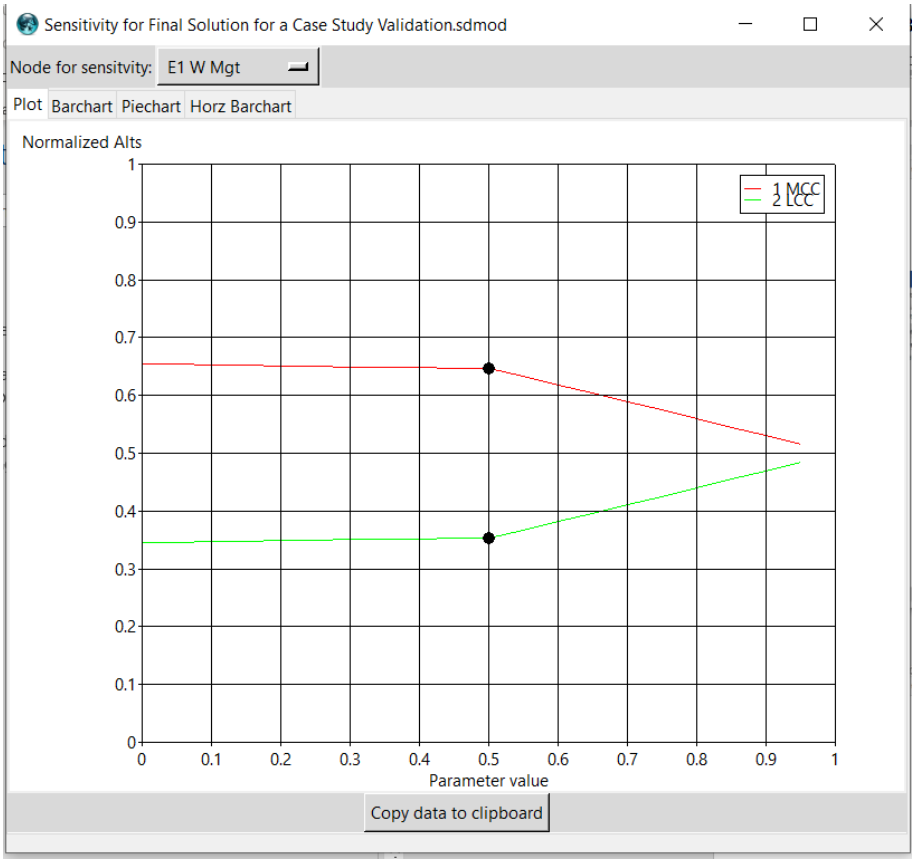
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Plot
Barchart
Piechart
Horz Barchart
Normalized Alts
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2 LCC
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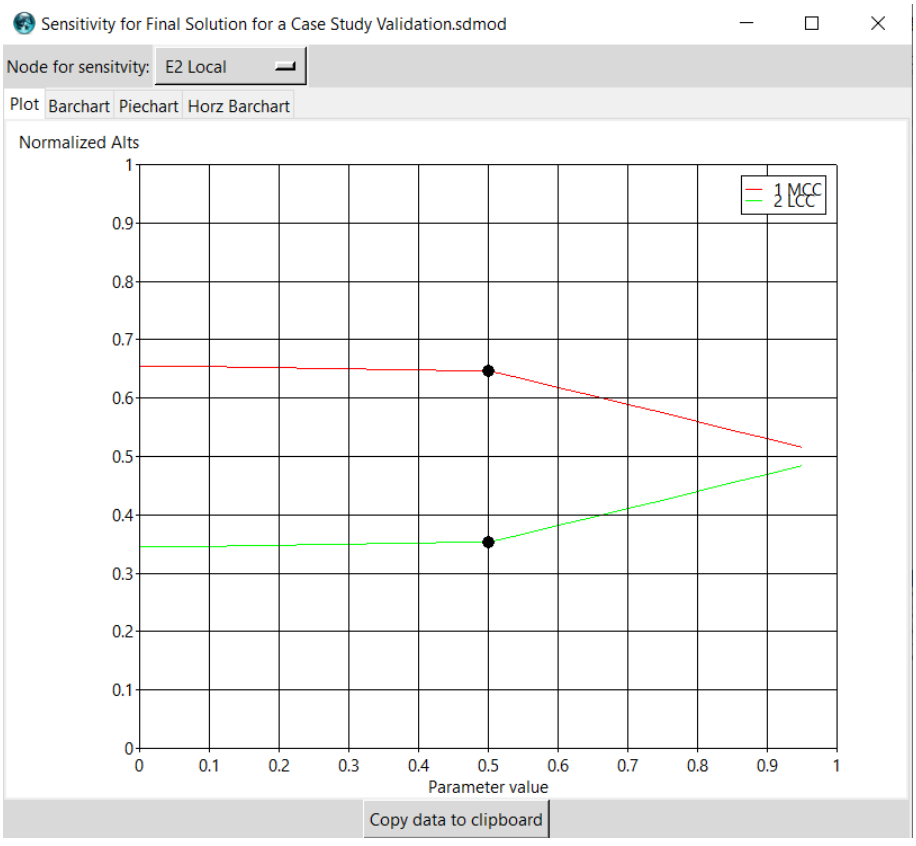
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Barchart
Piechart
Horz Barchart
Normalized Alts
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2 LCC
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Parameter value
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