SUSTAINABLE INFRASTRUCTURE DELIVERY IN NIGERIA: IMPLEMENTATION OF THE ANALYTIC NETWORK PROCESS FOR CONTRACTOR SELECTION

Purpose

This paper presents research findings that involve the use of Analytic Network Process (ANP) to select contractors for Build-Operate-Transfer (BOT) infrastructure in Nigeria. To deliver sustainable infrastructure, a responsive methodology is required during selection process to combine judgement and data to effectively predict outcomes.

Design/methodology/approach

Theoretically grounded on a system theory, Sustainable Infrastructure Delivery (SID) model has been developed in this study. At the deductive phase of the model, is the integration of the analytic network process (ANP) (a multi-criteria decision making technique) data synthesis. To obtain research data, 55 sustainability indicators for contractor selection were first identified from literature reviews. The criteria were developed to a web-based questionnaire where respondents were requested to rank the importance of the criteria in contractors' selection using Likert scale of 1 – 5 (where '5' is very important' and '1' is not important). The results were first analysed using Factor Analysis. Data were reduced to 16 variables after multicollinearity issues in the dataset had been resolved. To weigh relative importance of criteria among contractors, ANP methodology was adopted for the second-round survey. 7-man decision panel that completed pairwise comparison survey were selected through a purposeful sampling technique. The final results were synthesised by *Super Decisions* (computer package that implements ANP) to rank contractors' options and predict outcomes.

Findings/results

Sensitivity analysis reveals that 16 criteria have differential comparative advantages that requires critical evaluation during contractor's evaluation. Though overall priorities rank MCC higher, they are not absolute to deliver sustainable infrastructure. Sensitivity results show LCC perform better in some key selection criteria.

Originality/value

This study fills the gap in the knowledge of sustainable infrastructure procurement in Nigeria. The study theoretically suggests a framework to harmonise sustainability indicators in contractor selection. The results provide feedback which can be incorporated in government ministries and agencies future procurement policy to ensure sustainable infrastructure delivery.

Keywords: Sustainable infrastructure, Poverty, Analytic network process, System, Build-Operate-Transfer, Nigeria

1.0: Introduction

Sustainable infrastructure delivery is a broad concept and it embraces the design, building, and operation of constructed facilities in such a way that promote sustainable development (SD). Due to contemporary issues in construction industry in developing countries (DC) (Du-Plessi, 2007, Kaming et al., 1994), the United Nations (UN) identified the need for global partnership for development in the strive towards eradication of poverty in DC (Du-Plessis 2007). At the top of the millenium declarations by the UN, in September 2000, was the eradication of extreme poverty and hunger in DC. According to Omotola (2008), "poverty connotes a condition of human deprivation or denial with respect to the basic necessities of life: food, shelter, and clothing". Another school of taught describes poverty as a development problem (Moyo, 2002). This is case of omission of essential element during a development programme.

Despite numerous studies on construction activities in DC (Babatunde and Low, 2013; Ofori, 2001), conceptual framework of the implementation of social procurement in DC is not substantial. The ideology of social procurement is the use of procurement to foster social benefits and values for the communities beyond the purchase and consumption of goods and services. Construction sector is globally recognised as a sector of the economy that promotes social development through procurement programme (Babatunde and Low, 2013). Meanwhile, Ofori (2001) argued that construction industry development programmes in DC are merely '*shopping list'* where coordinated series of planned activities, which optimise systemic value delivery, are missing. The worldviews on poverty by Omotola (2008) and Moyo (2002) could well depict level of social progress (Ajufo, 2013; FGN, 2012; Omotola, 2008), and challenges of sustainable infrastructure delivery in Nigeria (Opawole and Jagboro, 2016a).

While global partnership for development is advocated for poverty eradication, Moyo (2002) rebuffed the claim that poverty is endemic to DC; rather it is embroiled in economic engagement between developed and developing worlds. Poverty in Nigeria, and DC at large, could be discussed in its richness, based on its drivers. Moyo (2002) and Ofori (2001) believed that development problem is the bedrock of poverty in DC. While the solution to poverty eradication in DC relies upon internal development programmes and global collaboration, capitalism has urge economic and political influences in procurement decision. Multinationals could exercise their political strength and economic leverage to cripple economic, social, community, and technical sustainability of the host nation (Taylor, 2007). The grant of the *'right of first refusal'* to multinational construction corporations (MCC) in Nigeria (Taylor, 2007) further sanctions absolute control being exercise by the multinationals during contract formation. Hence, responsive poverty eradication goes beyond mere collaboration for infrastructure delivery. There is a need for coordinated activities that can measure and review social progress and capability building in construction supply chain.

Despite growing knowledge of sustainable development in Nigeria (Oduyemi et al., 2018; Akadiri, 2015), selection of contractors that promote sustainable infrastructure delivery has not been well explored. The main aim of the paper is to develop a framework for contractor selection that promotes sustainable infrastructure delivery. The rest of this paper is organised as follows: Section 2 presents construction industry and social challenges in Nigeria. The chapter further discusses build-operate-transfer strategy and its onerous stakeholders' management. Section 3 discusses sustainable development and critical selection criteria for procurement sustainable infrastructure. Section 4 presents the overview of the analytic network process as a multi-criteria decision-making technique. Section 5 highlights rationale for research design and methodology. Section 6 demonstrates the implementation of the ANP. Section 7 and 8 present research findings and conclusions respectively.

2.0: Construction industry and social development

2.1: Construction industry and social challenges in Nigeria

Construction industry is a fundamental economic sector and it is globally acknowledged as a catalyst for SD (Babatunde and Low, 2013; Du Plessis, 2007). The sector promotes positive societal change due to its systemic effect on broader sectors (Babatunde and Low, 2013; Du Plessis, 2007) through demand for material and human resources. Available data concede to the overwhelming contribution of the construction sector to gross domestic product and human development in European Union (Egan, 1998). Egan report (1998) revealed that construction sector represents 40% of the capital projects in the UK, which account for 7% of gross domestic product (GDP). An average of 5% of the annual gross domestic product in Nigeria is generated from construction sector (Ogunsemi and Jagboro, 2006). Much recently, furthermore, studies have attributed 13.4% of global gross domestic product to construction industry and the index is expected to reach 14.6% by 2020 (Babatunde and Low, 2013). With growing demand for constructed facilities, about 50% on the Nigerian government expenditures is budgeted on construction projects (Ogunsemi D and Jagboro, 2006). With the level of the dearth of constructed facilities, it is estimated that around $12b - $15b investment is required annually for the next 10 years to solve infrastructure problems in Nigeria (Opawole and Jagboro, 2016a). These evidences further substantiate ability of construction industry as a driver for social progress through demand for material and human .resources.

Wistfully, socio challenges in Nigeria have remained almost consistent over the past decades (Ajufo, 2013; FGN. 2012; Idoro, 2010; Omotola 2008; Taylor, 2007). There are millions of populations that are languishing in extreme hunger and abject poverty (Ajufo, 2013; FGN, 2012; Omotola, 2008). Notwithstanding an average growth rate of 6.2% economy between 2002 and 2011 (FGN, 2012), over 70% of the Nigerian population are estimated to live on an average of a dollar ($) or less per day (Omotola, 2008). With a GDP second only to South Africa in Africa, Nigeria was rated absurdly low in key social indicators, which are per capita income, immunisation, improved sanitation facilities, and mortality rate when compared (Okonjo-Iweala and Osafo-Kwaako, 2007). The findings were further validated by a sustainable development report of 2012 (FGN, 2012), showing the disparity between GDP and poverty tend in Nigeria. In 2011, GDP had risen to 1.5%, using 6% of 2006 as the base point. Using 1980 as the basepoint for poverty trend, by 2010, it had risen by 50% above 25%. Unemployment level has risen from 3.8% in 2003 to a whopping 23.9% in 2012. The class of people that are most affected are aged between 18 and 35 (Ajufo, 2013). Extreme poverty and hunger is the driver for unhealthy macroeconomic environment in Nigeria, characterised with high rate of crime and related social vices (Ajufo, 2013; Omotola, 2008).

2.2: Social value and economic reform programme

Social value is becoming increasingly important evaluation criteria for contractors seeking to deliver public projects. This implies that contractors are not evaluated only on their proficiency to deliver quality infrastructure; they must be able to demonstrate how the delivery process will contribute to social progress. As part of social development agenda, in 2013, Social value Act was introduced in the United Kingdom. The act regulates government agencies to weigh 10 – 20% of tender on social value. The applied social value measurement metric includes the percentage of locals that would benefits from apprentices and eventually gain full employment with the contractor.

Following years of economic stagnation caused by military rule and poor economic management, the Nigeria government embarked on comprehensive economic reform programme during ‘fourth republic’, based on the National Economic Empowerment and Development Strategy (NEEDS) (Omotola, 2008; Iweala and Kwaako, 2007). The scopes of NEEDS are: 1) to improve the macroeconomic environment, 2) to pursue structural reforms, 3) to strengthen public expenditure management, 4) to implement institutional and governance reforms.

Weighing the correlation between unemployment and sustainable development, government further enacted the Nigerian Local Content (NLC) Act in 2010 (Ayomike and Okeke, 2015). The act is aimed at a systematic development of capacity and capabilities through the deliberate utilisation of local human, material resources and services in the key economic sectors (Ayomike and Okeke, 2015).

Iweala and Kwaako (2007) highlights the central objective of the government macroeconomic reform was to stabilise the economy, to improve budgetary planning and execution, and to provide a platform for sustained economic diversification and non-oil growth. With the level of investment is required annually for the next 10 years to solve infrastructure problems in Nigeria (Opawole and Jagboro, 2016a) and the significance of construction sector of the economy in sustainable development (Babatunde and Low, 2013; Du Plessis, 2007), cash budgetary was a major challenge faced by the ministries, department and agencies (MDAs) to meet demand for public infrastructure. As such, interest was shifted to infrastructure delivery through public-private partnership (PPP) initiatives. This led to the establishment of the Infrastructure Concession Regulatory Commission (ICRC) was established under ICRC Act, in 2005. The agency is responsible for the development and implementation of PPP framework for infrastructure procurement. The principal goal of the agency is to attract construction contractors that can build and finance capital projects for MDAs (ICRC, 2012).

2.3: Build-operate-transfer strategy in Nigeria

BOT model is often referred as a core PPPs due to a substantial amount of risks being transferred to the private sector (Opawole and Jagboro, 2016a; Al-Azemi et al. 2014; ICRC, 2012). Other myth of BOT includes reliance on private funding as a debt relief for the government, transfer of project risk and burden to the private sector, technology transfer and training of local skills. The strategy involves granting of franchise or concession by the public or private to private entity referred as the concessionaire (Al-Azemi et al. 2014) for the procurement of infrastructure. Concessionaire, otherwise known as project consortium or special purpose vehicle (SPV), is a group of private investors. SPV provides funds for the construction of infrastructure and operate it for agreed period before the structure is returned to the public. SPV takes the responsibility for the project finance, construction, operation and maintenance of constructed facilities over concession period. 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. Though BOT has gained global recognition back to 19th century (Al-Azemi et al. 2014), it is at the experimental stage in Nigeria with first set of concession-based projects was commissioned around 2006 (Opawole and Jagboro, 2016a).

With the scope of BOT spanning to all mode of transportation, power projects, telecommunication, water supply, solid waste management, housing, education, agriculture, and health facilities, this buttress the significance of construction sector as it links to virtually all sectors of the economy. It also presents a special case for the integration of social values in selection criteria for contractors.

To date, public infrastructure procurement through BOT, in Nigeria, has witnessed unprecedented level. A boost is construction activities are presumed as a catalyst for brother economic sector (Babatunde and Low, 2013) and subsequent social development. Patil et al. (2016) observed that, in DC, private funding initiatives for public infrastructure funding lead to unequal development and social marginalisation. Perpetual poverty in Africa has been linked to global capitalism and free trade (Moyo, 2002). But it cannot be denied that development problems in the Nigerian construction industry span beyond free trade. Challenges of local contractors are evident in key factors of production, which include low quality of workmanship, lack of innovative approach and technology, inability to attract credit facilities, lack of innovative construction methods (Taylor, 2007; Kaming et al., 1994).

Furthermore, concerns have been raised on the integration on the effectiveness of the myth of BOT in contractor selection policy in Nigeria. Though present regulation on PPP strategies encourage the implementation of life-cycle-costing method to evaluate long term project costs (Oduyemi et al. 2018), only economic performances are often evaluated. Arowosafe et al. (2015) had contended that the evaluations of project's 'intangible costs' are often obscured during pre-construction cost evaluation.

3.0: Sustainable infrastructure and contractor selection

3.1: Sustainable development and sustainability indicators

The discourse on sustainable development is often underpinned by the evaluation of the human activities on environment, either material consumption or implication of material use and processing on the environment. The first global UN summit on sustainable development was in 1972. It was the unprecedented post-war industrialisation and economic boost. Concerns were raised on the continuous growth in consumption and their impacts on basic environmental limits. While various measures were implemented to manage sustainable development, the widely acceptance of the summary of SD in 1987 Brundland report of the World Commission on Environment and Development as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs has a profound influence on the modern-day interpretation of the concept of SD. This may be associated with the rationale of environmental issues being commonly used for sustainability indicators for construction activities (see Akadiri, 2015 and Ngowi, 1998).

While both developed and developing countries strive for SD, the level of development differs between geographical locations. Du-Plessi (2007) summarised SD as the management of the relationship between human needs and their environment as not to exceed critical environmental limits. Du-Plessi (2007) discussed factor that determine the level of the relationship between humans and their environment under two main factors that constitute a value system of a society. They are: 1-the interpretation of 'quality of life' in a society, and 2-the choices made in term of interrelated systems in a society, such related systems in the society, such as technological, political, economic system

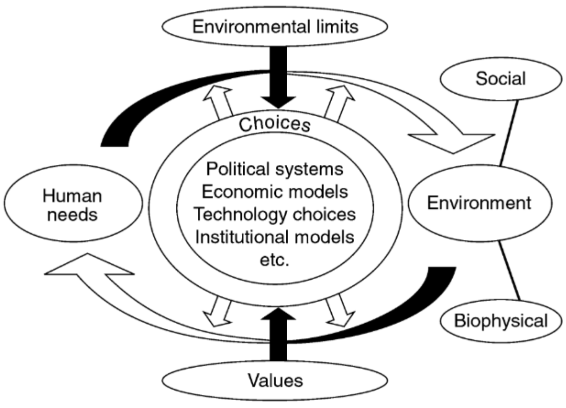


Figure 1: A relational model of sustainable development
Source: Du-Plessi (2007)

Figure1 concludes on differential SD between developed and developing countries. The value systems also further illustrate driver for a difference in construction development among nations.

Over the past decades, various programmes have been initiated to foster the development of construction industry in Nigeria, and DC at large had failed (Ofori, 2001). Despite decades of research in built environment, the problems have remained unsolved. Dated back to 1998, a meeting CIB Task Group 29 (TG 29) was held in Tanzania and the goal was to formulate indicators for the capture of progress of the industry in developing countries (Ofori, 2001). More recently, needs for improvement of socio-economic development in DC has attracted international attentions. The International Council for Research for Innovation in Building and construction (CIB) collaborated with UN and developed a programme for Agenda 21 for sustainable construction in DC (A21SCDC) (Du-Plessis, 2007).

Though problems of construction in DC include material and technology problems, financial problems, skilled human resources shortage, legal issue and polities, marketing and productivity problems (Kaming et al., 1994), they are systemic and go beyond social and economic issues. As a guide for best practice, British Standard (BS 8903: 2010) itemised key sustainability issues (see Table 1) that can be evaluated during decision making process on sustainable procurement.

Table 1: Examples of key sustainability issues

Environmental issues	Social issues	Economic issues
Emissions to air (e.g. greenhouse gases, such as carbon dioxide, and other pollutants).	Encouraging a diverse base of suppliers (e.g. minority or under-represented suppliers).	Job creation (e.g. green technologies, creating markets for recycled products, back to work schemes).
Releases to water (e.g. chemical pollution of water courses).	Promoting fair employment practices (e.g. fair wages, workforce equality, diversity, avoidance of bonded labour).	Understanding whole life costs to achieve value for money.
Releases to land (e.g. chemical fertilizers).	Promoting workforce welfare (e.g. health and safety, trade union membership).	Supporting small and medium enterprises (SMEs) (e.g. facilitating opportunities for small businesses).
Use of raw materials and natural resources (e.g. sustainable forestry, biodiversity).	Enabling training opportunities and skills development (e.g. apprenticeships).	Reducing entry barriers (e.g. facilitating open competition).
Use of energy (e.g. energy efficiency, renewables).	Community benefits (e.g. supporting community groups, volunteering).	Ensuring operating business remains a viable operation able to provide employment.
Energy emitted (e.g. heat, radiation, vibration, noise).	Fair trade and ethical sourcing practices (e.g. fair pricing policies).	Ensuring suppliers' agreements are at fair and viable margins.
Waste and by-products (e.g. recycling and waste prevention)		Ensuring business continuity (e.g. supply chain resilience).

Source: BS 8903:2010

3.2: Contractor selection for sustainable infrastructure delivery

Numerous attempts have been made by researchers to elucidate selection criteria for contractors (see Enshassi et al., 2013; Wang et al., 2013; Cheng and Li, 2004; Palaneeswaran et al. (2003); Palaneeswaran and Kumaraswamy (2000); Wong et al (2000). While selection criteria are well, developed, there is neither consensus on the number of criteria nor general theory that underlay the selected criteria. In general, frailty in contractor selection practice are lack of universal approach, long term confidentiality to prequalification outcomes, reliance on cost-based decision making and subjectivity of the process (Enshassi et al., 2013).

Common selection criteria that are consistently applied among clients include, past-experience, resources, current work load, past client-contractor relationship, safety performance, tender price, financial capability and past performance (Cheng and Li, 2004; Wong, 2000). 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). To delineate benchmark criteria for contractor selection, common expressions that have evolved among researchers were reviewed. Walraven and de Vries (2009) advocate for value driven contractor selection. Palaneeswaran et al. (2003) explore 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 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 tangibles. 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.

Though Palaneeswaran et al. (2003) advocated for best value in contractor selection, they consented to the ambiguity in best value concept, and the interpretation of value. For instance, in the context of usage of value by Wong et al. (2000), selection criteria are limited to conventional approach.

While different attributes of sustainable procurement have been identified, decision making would become complex and challenging due influences of various decision factors. Hypothetically, with the pluralisation of construction client in BOT strategy, economic factors remain non-substantial criteria for contractor selection. The biggest huddle that is faced by decision makers in public sector is the trade-off between stakeholders' stakes due to their impacts on project performance.

4.0: The analytic network process (ANP)

4.1: The overview

ANP is a decision finding method that can model a complex decision problem. The technique is a powerful synthesis methodology for combining judgement and data to effectively rank options and predict outcomes. The uniqueness of the technique is the shift from 'unidirectional' to 'close-loop' approach in the structure of a problematic decision. As such, it resolves the setback in commonly applied unidirectional mathematical approach to solve real life messy decisions.

Table 2: Literature review on the application of ANP

Project	Author (s)
Election of green marketable products	Neubert (2015
Integrating three-dimensional sustainability in distribution centre selection	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	Cheng and Li (2004)

Presented in Table 2 is the summary studies in the literature that demonstrate the efficiency and effectiveness of ANP in solving complex decision problems. Despite growing implementation of ANP for contractor selection, real costs underpin the decision clusters.

4.2: Paired comparison, the fundamental scale and consistency ratio

The ANP model is comprised of clusters of decision criteria and connection among them. The model allows for connections between nodes in a cluster or nodes between clusters as long there is a relationship between them. The technique offers a more realistic way to model a real-world scenario, by taking into considerations of the relationships that often imminent in decision process. These interactions help to capture the complex effects of interplay in human society such as trade-off between economic and social values in contractor selection for BOT project.

The methodology of the ANP is well elucidated in literatures (see Aragones-Beltran et al., 2010; Saaty, 2008; Cheng and Li, 2004). To measure relative importance of criteria, Professor Saaty has postulated a 9-point priority scale for obtaining judgement matrix, as shown in table 3.

Table 3: 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*	

Sourer: Adapted from Saaty (2008)

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: Pairwise comparison matrix

			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, 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}.

The formula: n(n-1)/2 is a guide for the number of comparison in matrix A. The reliability of judgements in the pairwise comparisons is determined by the consistency ratio (CR).

$$C.R.(A) = \frac{C.I.(A)}{R.I.},$$

…. 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

RI is an experimental value that depends on n. Assume n = 9, as shown in table 5, value for RI = 1.45.

Table 5: Random index

Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I.	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49	1.52	1.54	1.56	1.58	1.59
First Order Differences		0	0.52	0.37	0.22	0.14	0.10	0.05	0.05	0.04	0.03	0.02	0.02	0.02	0.01

Source: Saaty (2008)

5.0: Research design and methodology

5.1: Research design

Following the preliminary findings on BOT contract and construction stakeholders in Nigeria, systemic approach (Chinyio and Akintoye, 2008) was considered the most appropriate technique to design framework for contractor selection. As opposed to unidirectional approach to problem solving, systemic (i.e. closed-loop) structure of decision problem highlights the ideology of reductionist approach where complex processes are broken down into a few component parts in the form of selected sustainability indicators (Patil et al., 2016). The approach is applauded to be more effective and efficient in solving messy situation (Mardani et al., 2015; Cheng and Li, 2004). System approach is, therefore, considered as the most appropriate theoretical foundation to model contractor selection for BOT projects in public domain.

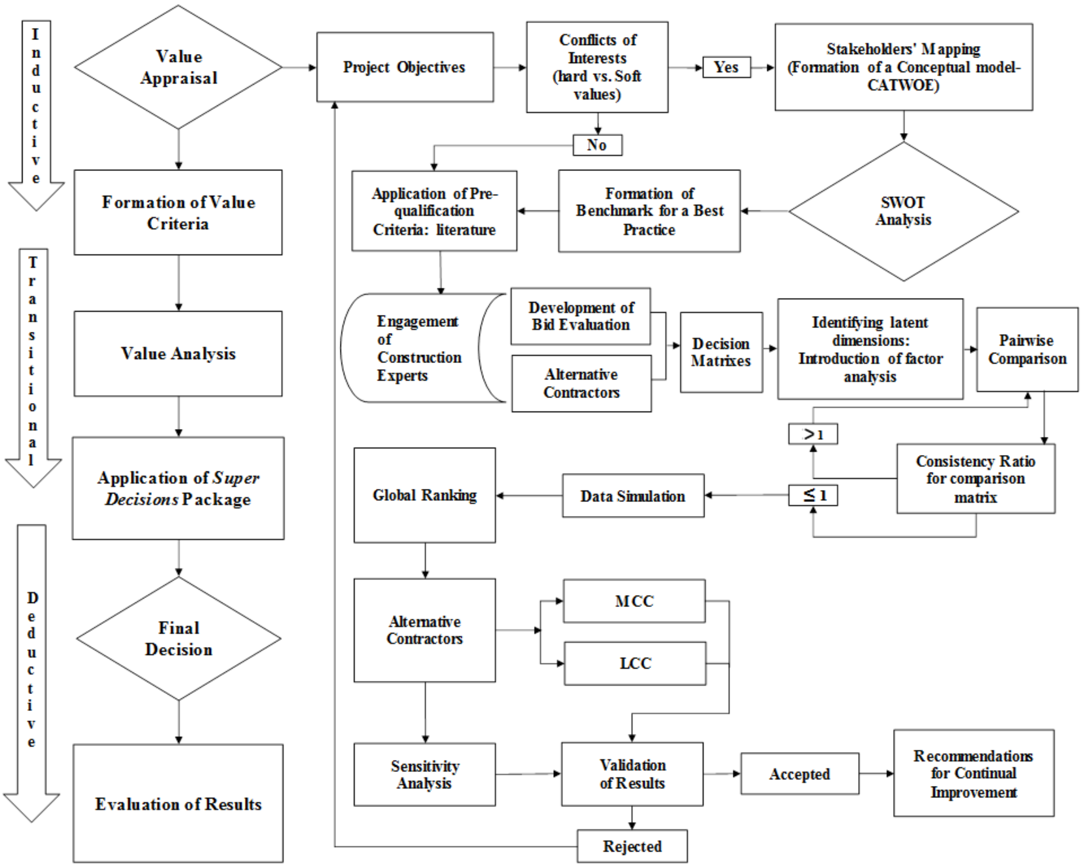


Figure 2: Proposed SID model for contractor selection

The proposed SID model in figure 2 can be simplified to 3 phases. The inductive phase is the broadest phase of the model. For this study, the goal of contractor selection is the deliver sustainable infrastructure. Objectives will include economic returns on investment, quality infrastructure and social progress, which can be measured in terms of local employment creation and capacity building. Transitional phase involves value analysis and data synthesis. With the support of decision making panel, decision criteria are structured ad prioritised with the implementation of ANP. Deductive phase is where data results are analysed, reviewed, and implemented.

5.2: Identifying criteria for contractor selection

Following in-depth literature review on contractor selection criteria, a total of 55 selection criteria identified were identified and designed to a questionnaire. The first-round survey involved the application of random and snowball samplings (non-probability sampling strategies) (Brammer and Walker, 2011), using web-based tool. The technique is cost effective and time saving and invaluable in reaching hidden population. Though probability sampling technique of data collection is easy to validate due to insignificant sampling error, the major challenge with probability sampling, as evident in this study, arises when sampling frame is not available (Brammer and Walker, 2011).

The questionnaire was designed to two sections. The first section comprised of general background information of a respondent. It aimed at gaining information on discipline, field of work, education level, and current position, nature of industry and awareness on BOT contract. In section two, respondents were asked to rank the importance of selection criteria on a five-point likert scale, where 5 represents ‘very important’ and 1 represents ‘not important’.

A total of 143 questionnaire feedbacks was analysed with the IBM SPSS Statistics 22. The descriptive analysis revealed the composition of respondents as 15% education sector, 18% government agency, 38% local construction company, 12% local manufacturing company, and 17% foreign construction company. The research findings further affirmed the claim by Adams (1995) that is considerable quantity of local contractor in Nigeria, though small in sizes and incapable to undertake complex civil engineering and building projects. The fewer MCC are found to execute over 90% of total value of construction contract (Idoro, 2010).

To verify the suitability of dataset for factor analysis, the Kaiser-Meyer-Oikin (KMO) and Bartlett's test of sphericity were carried out to scrutinise the sampling suitability. The techniques are commonly used in the literatures (Asadzadeh et al. 2015; Oyedele and Tham, 2007). The KMO is the ratio of the squared correlation between variables to the squared partial correlation between variables. The statistics for KMO vary between 0 and 1. 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. A recommended minimum value for KMO is 0.50 (Oyedele and Tham, 2007). For Bartlett's test, maximum value should be 0.05 (Oyedele and Tham, 2007).

Table 6: 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

Source: Analysis of surveyed data, 2017

For the dataset in this study, as shown in Table 6, KMO value is 0.519 and it validate the suitability of the data for factor analysis.

Among the 55 datasets used for the study, there was an evidence of significant correlation among predictor variables based on exploratory factor analysis 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 for the dataset. This problem was resolved by eliminating variables for which most of values are greater than 0.05 and correlation greater than 0.9. More importantly, principal component analysis of factor analysis supported data reduction for the second-round survey that involved the implementation of ANP. By doing so, inherent challenges of conducting many pairwise comparison are minimised (Asadzadeh et al., 2015).

6.0: Application of ANP model to predict sustainability of contractor selection

6.1: Determining the weight of the criteria and contractors of the model

Table 7: Component matrix

	Component				
	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				
Waste management					.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. 5 components extracted.

Source: Analysis of surveyed data, 2017

The factors extraction (in table 7) were modified to clusters based on their lurking dimensions. Two broad classification of contractors identified from literature reviews, based on the ownership (Idoro, 2010), are branded as multinational construction corporations (MCC) and local construction companies (LCC) based on the ownership. The overall clusters and their nodes were modelled to pairwise comparison matrices to facilitated second-round questionnaire survey.

Table 8: Prioritisation of elements between clusters

Compare the following elements in the cluster '*Environment*' according to their importance upon element M10, *Financial security*, in the cluster '*Asset*'

Which has a greater influence?	☐	**M1**	☐	**M2**	☐	Equal Importance		
To what extent?	☐	Moderate	☐	strong	☐	Very strong	☐	Extreme

Source: Adapted from Aragones-Beltran et al. (2010)

As reported by Aragones-Beltran et al (2010), it is critical that decision makers (DM) have good knowledge of the decision problem. Purposeful sampling method was explored (Abidin and Pasquire, 2005) to select construction experts who participated in pairwise comparison survey. Using social media and networking, 15 experts in the Nigerian construction sector were pre-contacted and they were briefed on the ongoing research. 7 people expressed their commitment to participate in the pairwise comparison exercise. They comprised of two facility managers, three quantity surveyors, and one civil engineer and one construction manager. The entire team have achieved chartered status in their respective construction related disciplines. Also, they have been actively engaged in construction project procurement.

6.2: Calculating the priorities between elements of the cluster

Priorities were computed were computed between elements of the same cluster, and between clusters as long there was a relationship. The Super Decision (trial version was used for analysis of the survey results. The purpose is to determine which criterion is more influential and to what extent among the elements of a cluster. The software allows obtain the inconsistency index of each of the DM results.

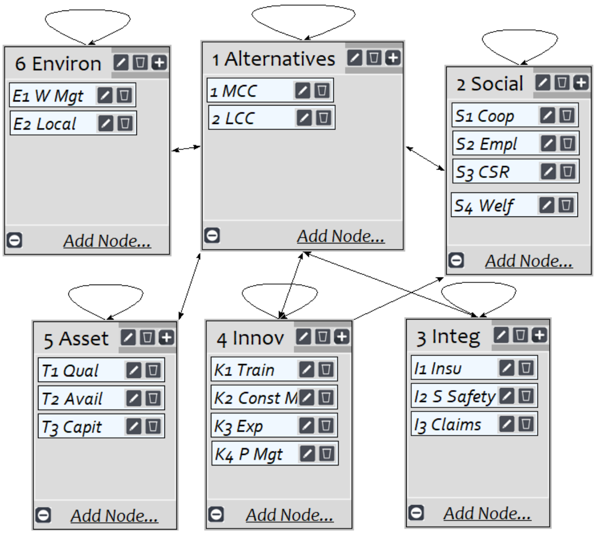


Figure 3: ANP-based contractor selection model in Super Decisions

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

The screen shot of the *Super Decisions* gives relationship information about decision nodes. 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 nodes'.

6.3: Computing unweighted, weighted and limit supermatrices

After the pair comparisons of nodes and the calculation eigenvectors have been completed, the software compute results for unweighted supermatrix. As shown in Figure 3, there are influences among elements of different clusters. The unweighted matrix is, therefore, non-stochastic by columns as the sum will be greater than one. To make supermatrix column stochastic, clusters must be compared to establish their relative importance and use it to weigh the supermatrix (Saaty, 2008). After clusters' priorities have been established, elements in each of the cluster were multiplied by the cluster priority, which result in weighted supermatrix. The weighted supermatrix was then raised to limiting powers until the weights converged and remained stable. At this point, limit supermatrix was obtained.

7.0: Analysis of results and sensitivity analysis

Due to limited space figures for unweighted and weighted supermatrixes are not showing. Table 9 is the results obtained after the weighted supermatrix was raised to limiting powers until the weights converged and remained stable.

Table 9: Limit matrix

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

Clusters	Nodes	1 MCC	2 LCC	S1 Coop	S2 Empl	S3 CSR	S4 Welf	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 Welf	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 4 contains 'limiting' and 'normalised by cluster' columns. 'Limiting' column are data obtained directly from limit matrix (table 9).

Figure 4: Nodes priorities

Here are the priorities.

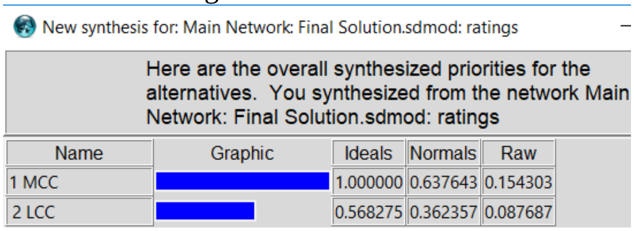
Icon	Name	Normalized by Cluster	Limiting
No Icon	1 MCC	0.63764	0.154303
No Icon	2 LCC	0.36236	0.087687
No Icon	S1 Coop	0.17365	0.029856
No Icon	S2 Empl	0.36714	0.063123
No Icon	S3 CSR	0.11161	0.019190
No Icon	S4 Welf	0.34760	0.059763
No Icon	I1 Insu	0.33614	0.028712
No Icon	I2 S Safety	0.41345	0.035315
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 4 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, there four nodes (S1, S2, S3 and S4), values of S1 = 0.17365, S2 = 0.36714, S3 = 0.11161, S4 = 0.34760. This mean by percentage of the priorities of the four nodes in ‘social skills cluster, S1 = 17%, S2 = 37%, S3 = 11%, and S4 = 35% respectively.

The results for the priorities of the alternatives, the number shown in the ‘raw column’ (figure 5) are directly from the limit matrix.

Figure 5: Final solution


New synthesis for: Main Network: Final Solution.sdmod: ratings

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Main Network: Final Solution.sdmod: ratings

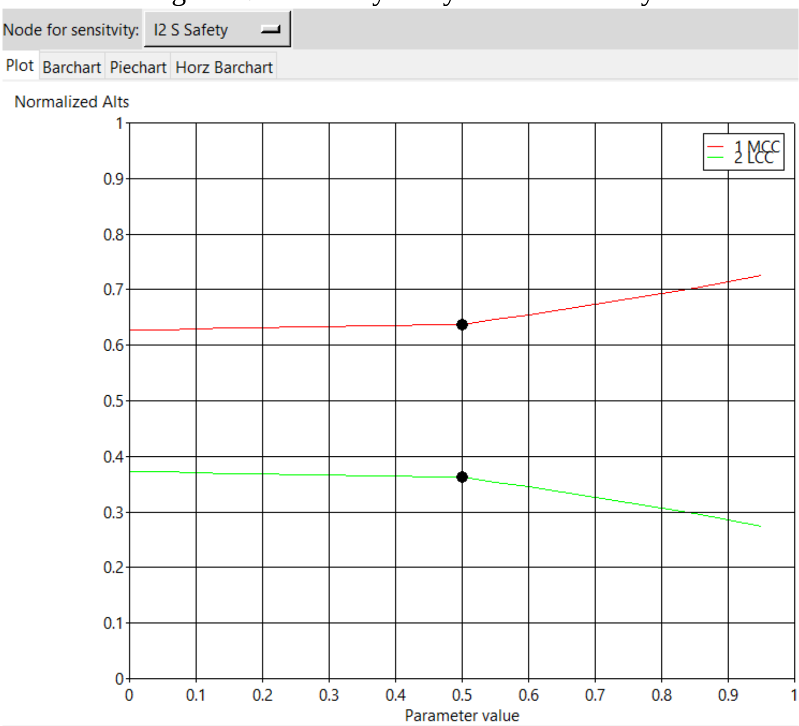
Name	Graphic	Ideals	Normals	Raw
1 MCC		1.000000	0.637643	0.154303
2 LCC		0.568275	0.362357	0.087687

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.

7.1: Sensitivity analysis

Sensitivity analysis, or what if analysis, may hold a useful insight to the alternatives being described based on a set of criteria. The approach involves observing relative impacts of slight modification of the priorities of elements of the network on the overall outcome.

Figure 6: Sensitivity analysis for site safety



The usefulness of the analysis is to inform on key criteria that require special attention due to higher improvement being achieved from a slight improvement. The results obtained from ‘node priorities’ in figure 5 were subjected to minor manipulations. Figure 6 is the sensitivity results for L2 (site safety). The result implies that the more priority given to site safety, the better to engage with MCC for better performance.

8.0: Conclusions

In this paper, SID model has been proposed as an innovative framework for contractor selection that promotes sustainable infrastructure delivery. ANP has been incorporated at the deductive phase of the model for data synthesis. Being a multi-criteria decision-making technique, ANP resolve the setbacks that are often associated with the application of linear arithmetic methods in evaluating contractor that deliver sustainable infrastructure.

The paper engaged on extensive literature reviews and identified 16 critical criteria that support contractor selection that promote SID. Based on their lurking dimensions, they were grouped to 5 decision clusters: *"asset"; "socio skills", "technical prowess", "knowledge", "integrity"*. To demonstrate the effectiveness and efficiency of the proposed SID model, paired comparison questionnaire survey was completed with the support construction experts. The criteria were computed for their relative importance for the selection of contractors for BOT projects.

The overall results predicted that MCC would perform better than LCC in SID, though they were not absolute. While MCC performed better on economic and environmental terms inclusion of local skills and resources remained key sources to social development. Okonjo-Iweala and Osafo-Kwaako (2007) noted that perpetual poverty due to the achievements of the economic reforms that fail to transform to welfare improvements for citizens. The final results revealed that applied 16 criteria differ in their sensitivity on achieving sustainable development. DU-Plessi (2007) re-iterated on the need for the creation of effective and efficient local construction sector to achieve sustainable development. Though MCC performed better on 'social responsibility initiatives', it is a self-regulated mechanism, evaluation of impacts of CSR on human development in DC remains a mammoth task. Extensive studies have proved there is no consensus view among researchers on the contributions of CSR towards environmental management and employment opportunities. From the findings, safety is very critical, and it influence overall project performance. Due to poor safety records of LCC (Idoro, 2010), LCC requires adequate training. To improve on the performance of local contractors, they must gain experience in projects of similar nature. Training becomes vital. Though local skills cannot effectively manage leading role, they should be structure to the production process. Ofori (2001) highlights key indicators and they include the number of workers skill tested, number of workers trained, and the number of supervisors trained. These would show that whole life costs of procured constructed facilities are well evaluated to achieve value for money (BS 8903:2010).

Compared with South Africa (Okonjo-Iweala and Osafo-Kwaako, 2007), much still need to be done infrastructure delivery to create improve microeconomic environment. The reliance largely on oil export earnings makes the Nigeria's economy ranked among the most volatile in the world. (Okonjo-Iweala and Osafo-Kwaako, 2007). The macroeconomic instability creates non-competitive environment for industrial production (Taylor, 2007) and drive outsourcing a preferred option by the MCC.

Regarding the detriment of paired comparison survey that is often voluminous, common in implementation of ANP, decision maker acknowledge that voluminous questions were involved in the survey, though they confirmed that the burden was lessen due to their experience and skills. They further commended the initiated of the factor analysis to eliminate less important criteria, which have significantly reduced the number of required matrices.

Overall, the proposed SID model has demonstrated the need for a shift in the modus operandi of the MDAs from unidirectional to systemic selection technique. It clearly demonstrated the appropriateness of the ANP to predict the contractor that delivers sustainable infrastructure.

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